



PROCEEDINGS

of the

36th

Annual Conference
OF

FISHERIES SOCIETY OF NIGERIA (FISON)

GARDEN CITY 2021

Theme:

**FISHERIES AND AQUACULTURE IN NIGERIA:
VERITABLE TOOLS FOR FOOD SECURITY AND
WEALTH CREATION AMIDST COVID-19 PANDEMIC**

Venue:

**EBITIMI BANIGO AUDITORIUM,
UNIVERSITY OF PORT HARCOURT,
CHOKA, RIVERS STATE**

Date:

24th - 29th October, 2021



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of the
36th Annual National Conference
of
FISHERIES SOCIETY OF NIGERIA
(FISON)

EDITED BY: O. A. AKINROTIMI (PhD)

“GARDEN CITY 2021”

24th –29th October, 2021

Held at
**Ebitimi Banigo Auditorium, University of Port
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EDITOR'S COMMENTS

All glory and honour be to Almighty God in the highest for enabling us to host a successful 36th annual conference of our revered Society tagged “Garden City 2021”. The conference lived up to its expectations as it attracted different people from many walks of life (academia, students, industrialists, artisans, etc.) who exhibited their aptitude, intellects and products. The Conference was adjudged as one of the best organized and well attended FISON meetings in recent times with over 400 in attendance (including students). This commendable accomplishment would not have been possible without the unquantifiable input and support of the Local Organizing Committee (LOC) led by Prof. A.I. Hart (*Ffs*). Worthy of special mention is the FISON Rivers State Chapter Executive members led by Dr. Nene Jamabo (*Ffs*) and the Conference Coordinator, Dr. Ebinimi Ansa (*Ffs*). The Conference was not without the usual challenges associated with hosting of international conference like ours, but by the grace of God and the cooperation of our members, we were able to surmount all the challenges.

The keynote speaker, Mrs. Ben. Okonkwo (*Ffs*) delivered her lecture on: **SHELL FISH AQUACULTURE IN NIGERIA: THE UNTAPPED GOLD**. The lecture was a masterpiece and an eye-opener in the unexploited area of shell fish production in Nigeria.

The technical sessions were interactive, educative and informative as it has always been in our conferences. However, in GARDEN CITY 2021 concerted and painstaking efforts were made to improve on some of the lapses that have been noticed at previous conferences; the schedule of presentation detailing day, time and duration of presentation as well as the session head and rapporteurs were made public some days before the commencement of the conference so that authors can have all the information necessary for their presentation. The session head and rapporteurs were also contacted ahead of time to notify them of their roles at the technical sessions. At every technical session, six presentations run concurrently and there was a total 24 technical sessions presented in three days.

The technical sessions were divided into seven thematic areas, namely: Fish Biology, Fisheries Management and Ecotoxicology; Fish Nutrition Processing and Product Development; Aquaculture Engineering, Culture Systems and Techniques; Gear Technology, Artisanal and Industrial Fisheries; Fish Breeding and Genetics; Fish Disease and Pathology and Fisheries Statistics, Economics and Extension. All technical sessions were intellectually engaging. During the presentation, authors were asked questions on their papers, while other observations and comments that will enhance the quality of the papers were pointed out for authors' inclusion in their manuscripts.

Two hundred and twenty six (226) manuscripts were received and presented at the conference while, Two hundred and one (201) papers met the editorial guidelines and requirements. Four of the papers were sent for further assessment into Nigerian Journal of Fisheries. The remaining twenty one papers (21) papers were rejected because of poor quality. Some omitted manuscripts from the past conferences were also included in the 36th book of proceedings.

Lastly, I would like to express appreciation to Dr. Simple Obi Godwin, Mr. Eze Uchenna, Mr. Ani Nwachukwu, Mr. Promise Nwosu and Mr. Felix Omodu for assisting in the editorial work as well as volunteered reviewers who sacrificed their precious time to peer review the manuscripts. Appreciation also goes to the National President, Dr. L.A. Agbabiaka for his overwhelming support towards the wonderful completion of the conference and the publication of the proceedings. Also, my sincere appreciation to Fisheries Society of Nigeria (Rivers State Chapter) for the confidence reposed in me and the opportunity to serve as the Conference Editor.

Akinrotimi Ojo Andrew PhD.
(Conference Editor, Garden City 2021)

COMMUNIQUE OF THE 36TH ANNUAL CONFERENCE OF FISHERIES SOCIETY OF NIGERIA (FISON) HELD AT UNIVERSITY OF PORT HARCOURT, PORT HARCOURT, RIVERS STATE, NIGERIA, 24–29 OCT, 2021

The 36th Annual Conference of the Fisheries Society of Nigeria (FISON), tagged “Garden City 2021,” took place in University of Port Harcourt, Port Harcourt, Rivers State, Nigeria from 24–29th October, 2021, with the theme – **Fisheries and Aquaculture In Nigeria: Veritable Tools For Wealth Creation and Food Security.**

The National President of FISON Dr. L.A. Agbabiaka in his opening address thanked the dedicated members of the 2021 Local Organising Committee (LOC) for their doggedness notwithstanding challenges here and there; especially the cooperation of the Chief Executive Officers of the hosting Universities namely University of Port Harcourt, River State University and Ignatius Ajuru University of Education all in the garden city. He informed the house on the progress so far made on the issue of the Fisheries bill before the National House of Assembly in Abuja. All things being equal, he believes by God’s grace very soon, the bill will be passed and accented to by the President. In concluding his address, he stated that papers to be presented in our conferences should be quality papers and not quantity. He further advised that researches in our various institutions these days should be demand driven, to solve some specific problems in the fishing industry and not mere academic exercises that will be consigned to the shelves after conference.

Keynote Address

The keynote address which was on **SHELL FISH AQUACULTURE IN NIGERIA: THE UNTAPPED GOLD**” was presented by Mrs. Ben. Okonkwo from private sector: Atlantic Shrimpers Limited, Lagos, Nigeria. In her address she talked on the possibilities, problems and prospects of shrimp culture in Nigeria.

Professor F.D. Sikoki thanked the keynote speaker. After much discussion of the paper, the Fisheries Society of Nigeria (FISON) resolved/recommended that government should

- Encourage investment in Shrimp culture in Nigeria
- Develop vital technological solutions to support shrimp culture
- Researchers should be trained on appropriate technology in shrimp culture
- Intensity fight against illegal fishing in our territorial waters
- Enforce stricter monitoring of pollutions, protection of nursery and fishing grounds from poachers and general habitat improvement.
- Promote shrimp production on a large scale, as this is capable of generating additional employment and income
- Declare a state of emergency on the aquaculture sub-sector, to address the constraints to shrimp culture which is majorly high cost of fish feed
- Private sector participation/improvement in shrimp culture should be encouraged
- Finally Government and the industries should fund extensive research on shrimp culture.

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ADDRESS BY THE NATIONAL PRESIDENT OF FISHERIES SOCIETY OF NIGERIA (FISON) DR AGBABIAKA, LUKMAN ADEGOKE, ON THE OCCASSION OF THE 36TH ANNUAL CONFERENCE OF FISON TAGGED “GARDEN CITY 2021” HOLDING AT UNIVERSITY OF PORT HARCOURT, CHOKA, RIVERS STATE.

Protocol,
Distinguished guests
Ladies and gentlemen.

I am delighted to address you again this year as our annual ritual at this very auspicious gathering; the 36th Annual Conference of the Fisheries Society of Nigeria (FISON) tagged “**GARDEN CITY 2021**” **with the theme: “FISHERIES AND AQUACULTURE IN NIGERIA: VERITABLE TOOLS FOR WEALTH CREATION AND FOOD SECURITY”** and the keynote topic: **SHELL FISH AQUACULTURE IN NIGERIA: THE UNTAPPED GOLD**”. I sincerely welcome you all for sparing your time to be here today irrespective of challenges of Covid-19, insecurity and economic challenges. It is my belief that the keynote speakers and plenary sessions will do justice to the topics. Permit me to thank the dedicated members of the 2021 Local Organising Committee (LOC) for their doggedness notwithstanding challenges here and there; especially the cooperation of the Chief Executive Officers of the hosting Universities namely University of Port Harcourt, River State University and Ignatius Ajuru University of Education all in the garden city here for their encouragements morally and financially despite the lean purse and security situations in Nigeria.

Reference to one of the major cardinal points of FISON which entails collaboration with Organisations/Societies and groups having related interests in the State, Nigeria and other parts of the world; FISON has consulted with the different tiers of Stakeholders including international agencies for the progressive growth of Fisheries and Aquaculture potentials of Nigeria; proposals were submitted already but our major limitation is funding we are expecting by His grace, else, we have the capacity to undergo Mapping of Fisheries Resources and Floodplains, compliment the inadequate staff strength of FDF&A in certification exercise and develop the very important National Residue Plan for Nigeria to enhance increase income, international trade development and improved livelihood of actors along the value-chain especially now that WTO is almost in place for fish trade competitiveness in West African Markets.

In order to achieve self – sufficiency in food fish production, a number of transformational programmes/projects have been recommended to the government. Among these programmes are the establishment of National Aquaculture Technology Transfer Centres, Demonstration Fish Farms, National Accelerated Fish Production Programme, Brood stock development, Capacity building in the areas of New Products development and the National Fish hatchery Development Projects. These lofty ideas impact were not effectively felt this year perhaps due to economic consequences resulting from dwindled foreign earning coupled with inadequate funding of Federal Department of Fisheries (FDF) that was usually budgeted to share less than 10% of the entire Federal Ministry of Agriculture and Rural Development (FMARD) with Livestock while almost 90% always go to crop and extension departments. It is our belief that Hon. Minister, FMARD and his team will increase our budget this coming 2022 having made robust presentation to the Government during the NATIP retreat of January, 2020 whose recommendations are yet to be implemented to date!

Our determination to reposition FISON has prompted us to initiate some reforms BUT our colleagues especially State Chapters are not cooperating! FISON NEC recommended last year to the chapters to furnish us with updates on membership in preparation for the expected FIN BILL 2021 almost ready at National Assembly and for planning. We recommended the use of REVISED MEMBERSHIP LIST TO BE HOSTED ON OUR WEBSITE and use of identity cards for professionals on duty and election purposes, to achieve these potential goals expected, we urge all concerned to please comply and send to FISON Headquarters all relevant information necessary before end of November, 2021; it is necessary that FISON Professionals need to be segmented according to ACADEMIC/PROFESSIONAL SPECIALITIES in order to have industrial relevance and not

business as usual ‘ JACK OF ALL TRADES’ henceforth! We urge us all to quickly re-register ourselves along this line soonest. FISON has developed a software on this for online registration. Having proposed this policy hitherto with little or no compliance, I want to inform us that only those who comply and send their profile with proof of specialization will be recommended for project development expected from FMARD, FAO and ECOWAS soonest; FISON leadership should not be blamed or blackmail of favouritism during the exercise.

The theme of this year’s conference “**FISHERIES AND AQUACULTURE IN NIGERIA: VERITABLE TOOLS FOR WEALTH CREATION AND FOOD SECURITY**” is not only apt but timely. This is the reason why we are here today, to discuss the challenges facing the Fisheries and Aquaculture industry in Nigeria and to proffer solutions.

FISON leadership is aware of dwindling numbers of *Trained Personnel* in our Ministries and Parastatals including the Academia and Research Institutes resulting in little or no industrial based outputs along their core mandate areas but digression! Hence, all hands must be on deck to restructure and ensure that our researches are to be more of industrial relevance and not just academic exercise! FISON will renew the society’s request to both National University Commission and National Board for Technical Education (NUC & NBTE respectively) on the necessity for the overdue syllabi/Curricula review in Fisheries and Aquaculture in order to overcome national and international challenges. The current syllabi used as prescribed by NUC and NBTE are grossly ineffective for the realities in the industry if our academic institutions are to be relevant. However, FISON leadership is appealing to our academic and Research institutions especially at Postgraduate levels to focus more on INDUSTRIAL BASED RESEARCHES as a panacea to usher in Technological greatness. FISON has also noticed recently, the embarrassing titles of our thesis/dissertations at Postgraduate levels including topics of inaugural lectures from expected giants in this specialized field BUT no appreciable improvements is noticed! We hope the FIN BILL assent will help us tremendously in this area.

As hitherto observed in previous years, it is very regrettable / unacceptable that almost all works on Aquaculture are not adaptable to farmers yearning because 80% of the Nutrition works often presented at our conferences are either in miniature AQUARIA or plastic bowls with duration of study average 6-8 weeks. Fisheries Management Studies are now with Desktop publishers without in-depth knowledge of Frame survey/ Stock assessment while Fish processing in Nigeria is synonymous to smoke-drying techniques without cognisance to the Phenol contents with valuable fish oil often wasted. Our observation to channel research in the area of FISH OIL from indigenous fish species to compliment/compete with the foreign fish-oil popularly called “*Seven Seas / Cod liver oil*” with an estimated 100million market annually in Nigeria without any significant locally competition over last 3 decades is yet addressed or popularised by our Universities and Research Institutes! This should be a challenge to all FISON professional in Nigeria; the resultant effects of tapping this hanging fruit will curtail capital flight, unemployment and deplorable livelihood with chaos.

Ladies and Gentlemen, permit me to express the disappointment of FISON leadership due to non-actualization of the Fisheries Institute of Nigeria Bill (**FIN BILL**) hitherto passed by 8th National Assembly but could not be immediately assented to by Mr President, Commander in Chief of Nigerian Armed Forces last year, hence, was time barred! We want to appreciate the drivers of the re-submitted **Fisheries Institute of Nigeria (FIN) Bill documents** now before the 9th National Assembly already transmitted to the Senate for concurrence since, March 2021 but actions yet completed. This was not targeted to FISON alone but many other bills hitherto passed by Green Chambers suffers same! Nevertheless, FISON was able to lobby for ours and it was scheduled for 17th October, 2021 which unfortunately coincided with the day President Muhammadu Buhari presented the 2022 budget before the Joint Chambers of NASS; therefore, we were asked to wait until the Senate resume from recess on 9th November for rescheduling. I want to thank the personalities in Green & Red chambers’ Committees on Agriculture for their encouragement each time I visit the National assembly on FISON issues, most especially **Hon. Tahir Monguno, Awaji-Inombek Abiante & Senators Adamu Abdullahi, Bima Enagi, Adamu Bulkachuwa and Aliyu Sabi**

respectively; I want to assure you that the passage of this charter document will usher a new road map towards socio-economic propensity of the industry in Nigeria. We shall present more of our activities in our score card during the Annual General Meeting (AGM).

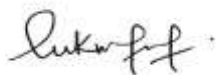
Ladies and gentlemen I want to once more on behalf of the National Executive Council and Council of Fellows of our great Society to thank the Garden city “2021” LOC for their commitment and dedication despite being more of women! I want to sincerely thank this chapter for cohesion and transparency that ultimately resulted in the success of their achievements. ***I shall be most pleased if the next President of FISON will be a woman from River State Chapter based on the transparency, sagacity and leadership qualities already displayed during my visits on planning to actualize this meeting.*** I want to appreciate the financial supports for this event, most especially the Executive Directors of NIOMR and NIFFR respectively, Skrettings Feeds, Aller Aqua Feeds Limited, Karflex Fisheries Limited, Atlantic Shrimpers, Premier Feeds, Vice Chancellors of Uniport , Ignatius Ajuru University of Education and River State University all in Portharcourt; among others too numerous to mention . I welcome you to this annual ritual and wish you all a fruitful stay and deliberation.

Long live FISON

Long live Rivers State

Long live the Federal Republic of Nigeria.

Thank you and God bless



AGBABIKA. L. ADEGOKE. *Ph.D, Ffs, MNSAP*

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Regional Vice President, West African Non-State Actors in Fisheries (ECOWAS & MAURITANIA)

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**FISH BIOLOGY,
FISHERIES MANAGEMENT
AND
ECOTOXICOLOGY**

1

Fish Diversity in Abraka Section of Ethiope River, Abraka, Delta State, Nigeria**Shaba S.A¹, Okolugbo B.C¹, Ikenga E.E², Olele N.F³, Garba, A.A⁴**¹Department of Animal and Environmental Biology, Delta State University Abraka²Department of Agricultural Education, Federal College Of Education (Tech) Asaba.³Department Of Fisheries and Aquaculture, Delta State University, Asaba.⁴Department of Aquaculture and fisheries, Faculty of Agriculture, Bayero University, Kano.**Abstract**

This study investigated fish diversity in Ethiope River in Abraka, Delta State, Nigeria. Two sampling stations (McCarthy beach and Rivotel beach) covering the Abraka section of the River were selected for the investigation. Fish sampling lasted for a period of eight weeks (8weeks). A total of one hundred and fifteen (115) fishes belonging to eleven (11) families were identified during the period of study. Results from the analysis showed that the Abraka section of River Ethiope was dominated by *Tilapia* species (35.65%) and the least was *Citharinus* and *Phago* species (0.87% each). The rich assemblage of fish species harvested indicated that the water body has the potential for fish production if properly managed. Intense fishing was an additional factor that influenced the poor status of the fish diversity. Results from specie richness, dominance, evenness, suggests that there is a threat to the sustainability of fisheries in Abraka section of Ethiope River. Future planning and management of fisheries resources, as well as participatory research is recommended to remove threat to the water body.

Keywords: Fish diversity, Assemblage, Ethiope River, Sustainable exploitation

Introduction

Fish constitute almost half of the total number of vertebrates in the world with about 21,723 living species of fish out of 39,000 species of vertebrate are so far recorded (Ali *et al* 2015). Fishes have been found to exhibit enormous diversity in their morphology, habitat and their biology. They live in almost all conceivable aquatic habitat. India is one of the mega biodiversity countries in the world and occupying ninth position in terms of fresh water biodiversity (Ali *et al* ., 2015). A comprehensive understanding of the dynamics of a fish population is an important management tool for the sustainable exploitation of any fisheries resources. Thus biological surveys of fish species composition and diversity is regular features in the managements of fisheries (Ali *et al* 2015).

The study provided accounts of the fish diversity and species composition in Abraka section of Ethiope River. Despite several studies, there is still scarcity of information in Nigeria aquatic ecosystem, hence the need for this present study of fish diversity, fin fish specie composition and distribution of River Ethiope. The study will therefore contribute to the much needed information on the specie composition, diversity and relative abundance fish in Abraka section of River Ethiope of Nigeria. The information here will serve as a baseline data for carrying out further study on ecology, conservation, sustainability, and management of fisheries resources of the water body.

Materials and Methods**Study Area**

Abraka lies approximately on latitude 5.48 and 6.06E. It is situated at the Eastern bank of river Ethiope in Ethiope east local government area of Delta State, Nigeria. Abraka covers a total land area of about 21.2² kilometres (Ufuoma 2000). River Ethiope (latitude 6⁰⁰⁰- 6⁰³⁰N and longitude 5⁰⁰⁰- 6⁰⁰⁰E) is a clear oligoinic fresh water river which took its source from Umuaja in Ukwani Local Government Area of Delta State. The river stretches from Umuaja through Obiaruku, Abraka, Eku, Aghalokpe, Mosoga down to Sapele.

Experimental Design

The study was designed to have two sampling stations covering the Abraka section of the river Ethiope. The two sample stations were titled station A (Latitude 6.89E and Longitude 4.92N) and station B (Latitude 6.89E and Longitude 4.923N).

Sampling Station location

Fish samples were collected from two stations namely MacChatty and Rivotel with the help of a fisherman using indigineous fishing methods and by using different types of nets namely gill nets, fishing spears, and dragnets. The experiment lasted 8 weeks.

Fish samples collection, treatment and preservation

Fish samples were harvested at both stations by a fisherman on a fortnightly bases, using wide range of fishing gears (gillnet, fishing spear, hook and line and nets of different mesh sizes). Fish samples were collected from the local fishers as he landed the river bank, and sorted into species and families prior to data collection. Collected fishes were preserved in plastic buckets containing 40ml of formalin and 960ml of water which was taken to the field. Identification of each species was done immediately after harvest in Animal and Environmental Biology Laboratory, Delta state University, Abraka. Fish diversity was determined using Shannor-wiener index (specie richness, specie evenness, margalef specie, specie dominance were calculated).

Fish diversity was determined using Shannon-wiener index (Krebs 1999) as follows:

$$\frac{N \log N - \sum F_i \log F_i}{N}$$

Where F_i = the population of individuals found in the species

N = is the number of the individuals species

Data analysis

The data was analysed using the computer package SAS (1999) to calculate the analysis of Variance (ANOVA) at a probability of <0.05, to compare the composition of the various species.

Results

A total of eleven (11) fish species belonging to eleven (11) families were collected from Abraka section of River Ethiope during the period of study. A list of the fishes is presented in table 1. The diversity of fishes in the Abraka section of River Ethiope revealed a total of 115 fishes belonging to 11 families. The Abraka section of River Ethiope from this study was dominated by *Tilapia* (35.65%) followed by *Brycinus* (30.44%), then *Hemichromis* (15.65%), and least with *Citharius* and *Phago* (0.87%) as shown in table 1.

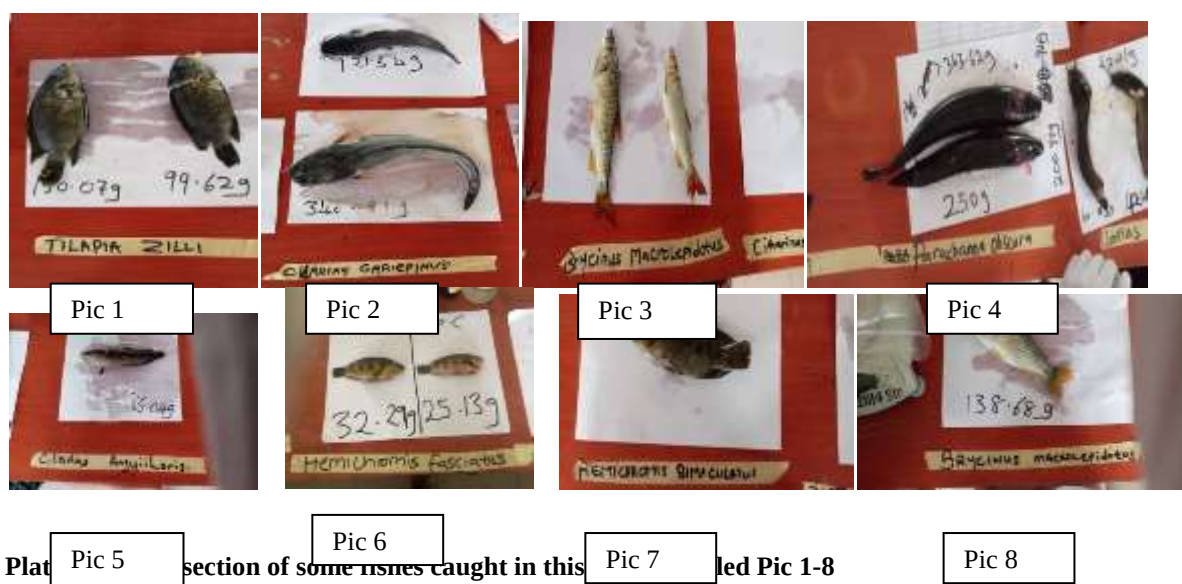
The weekly ratio of the caught fish was analysed in table 2. Week 4 and 8 recorded the highest number of fish caught as 16.53% of the total population of fish during this study, followed by week 7 (13.91%), week 5 (13.04%), week 6 and 2 was 12.17%, while week 1 was 8.70% and the least was observed with week 3 (6.96%).

Table 1: Species diversity

Names	Total number of fishes caught	Species distribution (%)
Brycinus	35	30.44
Tilapia	41	35.65
Hemichromis	18	15.65
Distchodus	3	2.61
Hydrocynus	2	1.74
Clarias	4	3.48
Labeo	6	5.22
Papyocrannus	2	1.74
Citharius	1	0.87
Parachanna	2	1.74
Phago	1	0.87
Total	115	100

Weeks	Number of fishes caught	Percentages (%)
Week 1	10	8.70
Week 2	14	12.17
Week 3	8	6.96
Week 4	19	16.52
Week 5	15	13.04
Week 6	14	12.17
Week 7	16	13.91
Week 8	19	16.52
Total	115	100

Table 2: Fishes caught during the duration of 8weeks



Plat section of some fishes caught in this led Pic 1-8

Discussion

The result on the fish species richness of these two reservoirs are comparable to those documented by Lamai and kolo (2013) from Dan-Zaria dam as well as those reported by Mohammed and Omoregei (2004) from Doma lake. Two *Siluriformes* species- *C. nigrodigitatus* and *S. intermedius* formed a significant portion of the fishes recorded from the two reservoirs. These fish families have been reported to constitute the major fisheries of the inland waters in Nigeria, due to their ability to adapt to various water conditions. The diversity indices employed in this study showed that Abraka section of Ethiopie River is very diverse. Research has shown that a more diverse ecosystem is better and makes the fish able to withstand environmental stress and consequently more productive, than a less diverse ecosystem. Patrick and Strydom (2007). This study recorded fewer number of fishes as reported by Gratwicke *et al* 2003. Gratwicke *et al* 2003 reported the presence of predators as one of the major factors that negatively influence fish specie richness and abundance. The effect of intense fishing is an additional factor to the poorer status of the fish diversity of Abraka section of Ethiopie River. It was observed that so many fishermen carry out fishing activities in this water body, as they sell their catch to the market women waiting at the river bank, and to students for research purpose. This has done more damage than good to the ecosystem of the water body also leading to depletion of fish specie. This study makes it clear however that there is threat to the sustainability of fisheries in Abraka section of Ethiopie River, Abraka as the fish specie recorded were few.

Conclusion and Recommendation

The rich assemblage of fish species collected indicates that these water bodies have the potential for fish production if properly managed. The intense fishing affects the diversity of fish in River Ethiopie resulting in the poor number of fish species recorded in this study. This makes it clear that there is a threat to the sustainability of fisheries in Abraka Section of River Ethiopie

References

- Ali A., Addo S., Lawan Z.A., Ebenezer A., (2015). Feeding habit and condition factor for *Oreochromis niloticus* in lake Alau, North Eastern Nigeria. *Int. j. Fish Aquatic stud.* 3(1); 406-409.
- Gratwicke .B., Marshall B.E., Nhiwatiwa .T. (2003). The distribution and relative abundance of stream fishes in the upper Manyame River, Zimbabwe, in relation to land use, pollution and exotic predators. *African Journal of Aquatic Science* 28(1): 25-34.
- Lamai .S.L., Kolo .R.J (2013). Biodiversity and abundance of fish and plankton OF Dan-Zaria Dam, Niger State Nigeria. *Journal of Aquatic Science.* 18(2):141-148
- Mohammed S.U and Omoregie E. (2004). A preliminary investigation into the fisheries potentials of Doma lake, Nasarawa state, Nigeria. *Journal of Aquatic Science.* 19(2): 59-64.
- Odo G.K.,Nwani C.D., Eyo J.E. (2019). The fish fauna of Anambra river Basin, Mageroa specie abundance and morphometry. *Revista de Biologica Tropical* 57(1-2);177-186.
- Patrick .P. and Strydom N.A. (2007). Composition, abundance, distribution and seasonality of larval fishes in the Mngazi Estuary, South Africa . *African Journal of Aquatic Science* 32(2); 113-123.

2

Species Composition, Abundance And Diversity of Fish Fauna of Yewa Lagoon, South-West Nigeria

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Abstract

A study of the fish fauna of Yewa Lagoon was carried out monthly from April 2017 to March 2019. Fish samples were procured from artisanal fishermen operating in the lagoon who used different kinds of fishing gears such as cast nets, set nets, gill nets, circling nets, bamboo traps, baskets, drums, hook and lines as well as fencing with acadja. Fish species were sorted and identified with relevant identification keys. Forty-three fish species belonging to 25 families were recorded in this study. *Chrysichthys nigrodigitatus* belonging to the Family Claroteidae was the most abundant (61.65%) fish species recorded and occurred throughout the study period. The least abundant fishes included *Tilapia guineensis*(0.04%), *Sarotherodon galileus*(0.04%), *Dagichthys lakdonensis*(0.04%), *Ormitator lebretonis*(0.04%), *Malapterurus electricus*(0.04%) and *Parentropius buffei*(0.04%). Higher abundance was recorded in the rainy season (62%) compared to dry season (38%). Highest species richness ($D=3.94$) was recorded for the Family Gobiidae while the lowest ($D=0.51$) was recorded for the Family Nothobranchiidae. The Family Clarotidae had the highest species diversity ($H=3.04$) while Nothobranchiidae had the least diversity ($H=0.60$). In the wet season, Gobiidae was the richest in species ($D=2.43$) while Clarotidae was the most diverse group ($H=2.51$); the pattern was similar in the dry season, $D=1.97$ for Gobiidae and $H=2.17$ for Claroteidae. Thirty-eight species out of the total taxa were found in the rainy season while 24 were recorded in dry season and 20 species occurred in both seasons. Yewa Lagoon has the potentials and capabilities to support fishery activities in the surrounding communities if well managed.

Keywords: Species composition, abundance and diversity, fish fauna, Yewa Lagoon

Introduction

The importance of fish can never be over emphasized as it serves many purposes aside sources of protein to man and other animals. Fresh water bodies in Nigeria have been reported with high diversity of fishes (Olaosebikan and Raji 2013). Ichthyofauna species composition, abundance and diversity are vital in the study of productivity potential and management of resources in a particular aquatic ecosystem. Yewa Lagoon is located in the western part of Lagos state being one of the nine known lagoons in the coastal system of Nigeria. It is useful for fishing, sand mining, transportation, and sink for wastes as well as other anthropogenic and economic activities. Fishing is one of the most important occupations of the people in the surrounding villages.

Most of the studies in the south-west lagoons have been focused on Lagos Lagoon (Ajagbe *et al.* 2012; Oluwajoba *et al.*, 2017) Lekki Lagoon (Emmanuel and Osibona 2013) Badagry and Ologe Lagoon (Soyinka and Ayo-Olalus 2009). Apart from the work carried out by Bamidele *et al.* (2015) on the diversity of *Tilapia* in Yewa Lagoon, there is a dearth of information on the entire fish community of the lagoon with regards to its abundance and diversity. Therefore, the objective of this current study was to provide scientific information on the species composition, abundance and diversity of fish fauna of Yewa Lagoon which will be of help in management and exploration of the available fisheries resources.

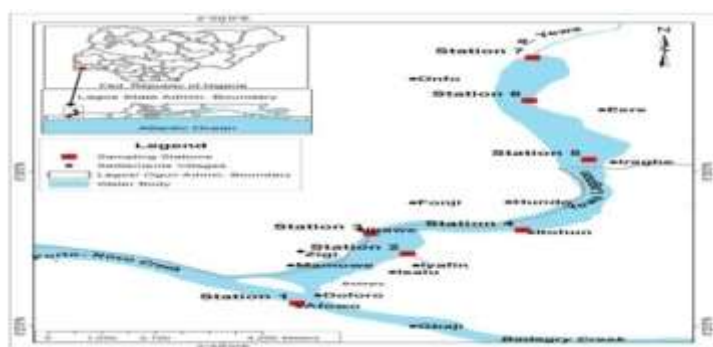


Figure 1. Map of the study area showing the sampled stations.

Fish sampling

Fish samples were purchased from fishermen and fish mongers operating in the lagoon.

Identification of fish samples: In the laboratory fish samples were sorted and identified using fish identification guide according Idodo-Umeh (2003), Olaosebikan and Raji (2013). The mean abundance of each fish species collected was calculated. The abundance of individual species was estimated using the criteria described by Benechet *al.* (1983): $\geq 10\%$ = dominant, 1-9% = subdominant, $< 1\%$ (but caught more than once) = occasional, $< 1\%$ (and caught only once) = rare. The percentage composition by number of every fish taxa during dry and wet seasons as well as the entire period of study was computed. PAST statistical program (Hammer *et al.*, 2001) was used for the computations of abundance and diversity indices namely Margalef's index for species richness, Shannon-Wiener for species diversity and the equitability index for evenness of fish families as well as their monthly variations.

Results

Fish Species Composition and abundance

Table 1 shows the list of all the species of fish encountered during the sampling period from April 2017 to March 2019 with their percentage abundance in number. Forty-three species of fish belonging to twenty-five families were recorded in this study. *Chrysichthys nigrodigitatus* ranked highest in number throughout the sample periods while *Malepteruruselectricus*, *Sarotherodon galileus*, *Tilapia guineensis*, *Dormitator lebretonis* and *Dagetichthys lakdoensis* recorded the least abundance (0.041%) for the combined seasons as well as the wet season (0.066%) and were not found in the dry season. The family Clarotiidae recorded the highest in percentage abundance (61.645%) throughout the study period (63.559% - wet and 58.521% - dry) while the least abundance (0.041%, 0.066%) was recorded for the families malapteruridae, eleotridae and soleidae for the combined season and wet season respectively. The least (0.107%) abundant families in the dry season were Nothobranchiidae and Notopteridae. Fish species were also categorized based on their ecological origin; twenty-nine species were of freshwater origin, twelve species from brackish water while five were purely marine water fishes.

Seasonal and Monthly variations in abundance of fish fauna

Wet season recorded higher percentage abundance and species number (N=62%, #=66%) compared to dry season (N=38%, #=34%) during the study period. Monthly variations in the abundance of all the fish sampled as well as the number of individual species recorded per month from April 2017-March 2019 is as shown in figure 2. The month of September 2017 had the highest number of species while the least was recorded in November 2018. The highest abundance was recorded in the month of April 2017 while the least was recorded in the month of November 2018.

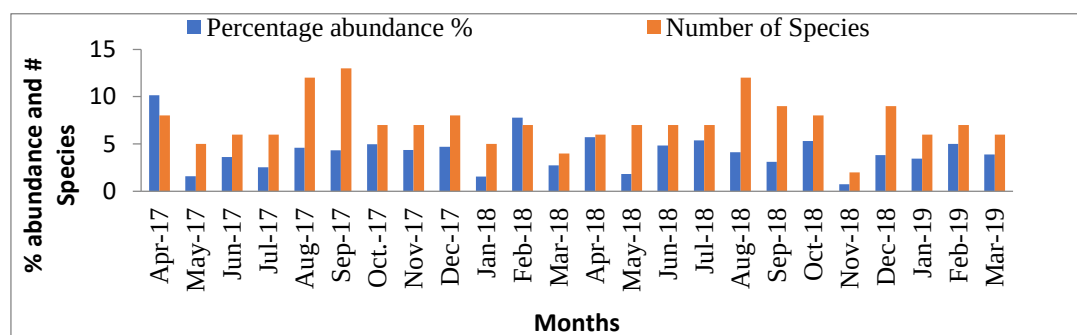


Figure 2. Monthly variations in abundance and species number of fish during the study period

Fish Diversity

The family Gobiidae recorded highest value in species richness throughout the (D=3.94) study period wet (D=2.43) and dry (D=1.97) seasons while the least was recorded for the families Nothobranchiidae overall (D=0.51), wet season (D=0.26) and dry season (D=0.38) for the family Elopidae. The most diverse family throughout the study period was Clarotiidae (overall H=3.04, wet season H=2.51 and dry season H=2.17) while the least in combined seasons and wet season was the family Nothobranchiidae (H=0.60 & 0.51) respectively; meanwhile the family Elopidae had the least during the dry season (H=0.52). The family Hepsetidae recorded the highest in evenness for overall and wet season (J=1.00) while the family Channidae had the highest for dry season (J=0.97). The least in species evenness for the overall was Nothobranchiidae (J=0.55) and for the wet and dry season was Schilbeidae (J=0.73 & 0.64). Zero diversity was recorded for the following families: malapteruridae, eleotridae, haemulidae, ophichthidae and soleidae during this study. In the wet season the

family Gerreidae recorded zero diversity while in the dry season the following families recorded zero diversity: polynemidae, monodactylidae, alestidae, clupeidae, hepsetidae, notoptyridae and Notobranchiidae.

Monthly variations in diversity are presented in figure 3, highest species richness ($D=2.57$) was recorded in September 2017 while the least ($D=0.35$) was recorded in November 2018. Species diversity was highest ($H=1.61$) in the month of February 2019 while the least ($H=0.21$) was recorded in November 2018

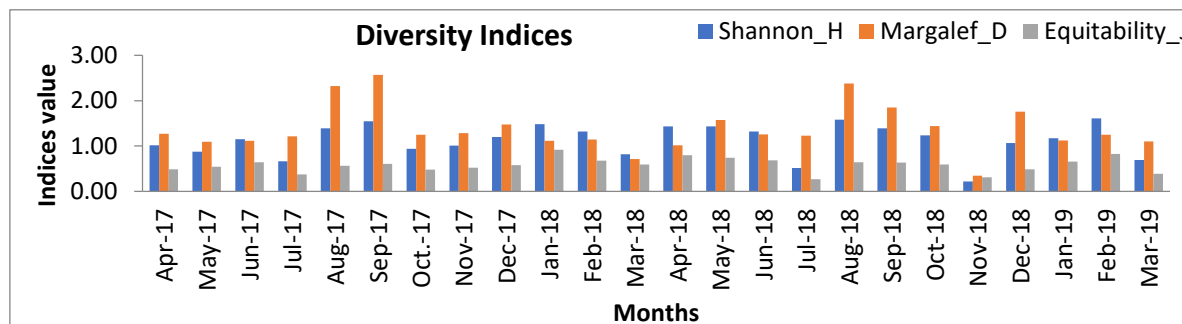


Figure 3. Monthly variations in fish diversity during the study period (April 2017-March 2019).

Discussion

The results of this study indicated that the fish assemblage of Yewa lagoon was moderate. Forty-three species of fish belonging to 25 families recorded in this study is similar to the report of 43 species (17 families) by Yakub (2012), 45 species (24 families) by Meye and Ikomi (2008), 49 species (28 families) by Oluwajoba *et al.* (2017). Some authors have recorded species compositions higher than this in different water bodies. Fagade and Olaniyan (1974) reported 72 species from 34 families for Lagos lagoon, Emmanuel and Osibona (2013) -81 species from 40 families for Lekki lagoon, Bolarinwa *et al.* (2016) 64 species from 39 families at Badagry coastal waters. However, the number recorded in this present study far exceeded the 25 species recorded by Olakolu *et al.* (2012) from Lagos coast, 18 species by Ajagbe *et al.* (2012) from Lagos lagoon, 19 species by Udo (2012) from Iba-Oku stream, 18 species by Arome *et al.* (2014) from Gubi Dam, 26 species by Akpan (2013) from Uta-Ewa creek, 11 species by Benson *et al.* (2012) from Lake Victoria Basin Kenya. Ecologically, 29 out of the reported species were fresh water fishes, 12 species were brackish while 5 were purely marine fishes. The presence of fresh, marine and brackish water fishes is an indication that Yewa lagoon is a transitional zone with varying degrees of salinity which serves as nursery and feeding grounds for brackish and marine water fishes. Though, almost fresh throughout the year, brackish and marine water fishes could have migrated into the lagoon during the periods of salt intrusion and high tide from the adjoining sea water (Meye and Ikomi, 2008; Oluwajoba *et al.* 2017). The fishes were also capable of thriving in unstable habitat based on salinity levels. Similar results have been reported by Akpan (2013), Emmanuel and Osibona (2013) as well as Ajagbe *et al.* (2012). Lagoons have also been known as nursery grounds for most marine and brackish water fishes as well as feeding grounds during high tides (Oluwajoba, *et al.* 2017).

The most important and dominant fish species in Yewa lagoon was *C. nigrodigitatus* (Clareotidae) and their success could be attributed to the muddy nature of the sediments, availability of food especially the gastropods which form the most important food items of this species as well as their ability to tolerate wide range of environmental conditions. The dominance of *C. nigrodigitatus* have been documented by some other authors, Akpan (2013) in Uta-Ewa creek, Oluwajoba *et al.* (2017) in Lagos lagoon, Bolarinwa *et al.* (2016) at Badagry coastal waters, Emmanuel and Osibona (2013) at Lekki lagoon. It forms the most important part of Yewa lagoon ichthyofauna making up more than 60% of the total catch. The least abundant species were also categorized as rare species since they were caught once throughout the sample period. They include *D. lebrtonis*, *D. lakdoensis*, *M. electricus*, *T. guineensis*, *P. buffei* and *S. galileus*. Most of these species were not cherished as food fish but very important in ornamental fish species. They may be ascribed as endangered and rarely seen in this water body especially *M. electricus* which is highly sought for in the Yewa community as a result of their fetish culture of offering it to their gods as sacrifice (personal communication). The low abundance and scarcity of these species may be attributed to abiotic conditions, gear selectivity, lack of preferred food items and culture of the surrounding villagers. Contrary to this report, *M. electricus* have been reported as the most abundant species in Iba-Oku Stream of Ikpa River Akwa-Ibom state by Udo (2012).

Higher abundance and diversity of fish were recorded in the wet season compared to dry season (though) and could be attributed to increased reproductive activities, availability of food materials during the wet season. Similar reports have been made by Emmanuel and Osibona (2013), Yakub (2012), Oluwajoba *et al.* (2017) and Idodo-Umeh (2003). The higher abundance recorded during the wet season however contradicts the reports

ofMeye and Ikomi (2008), Udo (2012), Bolarinwa (2015) and Bolarinwaet. *al.* (2016) as they recorded highest abundance during the dry season. These authors attributed the dry season high abundance and catch to more intense fishing efforts resulting to high catches during the dry season. The zero diversity values recorded for some fish families may be attributed to unstable environmental condition due to increased rate of anthropogenic activities which may lead to pollution stress.

Table 1. Fish Species composition and abundance during the study period (April 2017-March 2019)

Family	Species	Wet season %N	Dry Season %N	Overall %N
Claroteidae	<i>Chrysichthysnigrodigitatus</i>	63.559	58.521	61.645
Mormyridae	<i>Marcuseniussenegalensis</i>	4.071	4.93	4.397
	<i>Marcuseniusrucii</i>	2.889	0.643	2.036
	<i>Hippopotamyruspsittacus</i>	0.657	2.251	1.262
	<i>Mormyropsanguilloides</i>	0.131	0	0.081
	<i>Mugilcephalus</i>	0.985	9.003	4.031
Mugiliidae	<i>Bathygobiussoporator</i>	3.611	3.751	3.664
Gobiidae	<i>Gobiodessagitta</i>	0.394	0	0.244
	<i>Sarotherodonmelanotheron</i>	3.349	3.001	3.217
Cichlidae	<i>Hemichromisfasciatus</i>	0.591	1.929	1.099
	<i>Thyschromisansorgi</i>	0.394	0	0.244
	<i>Oreochromisaureus</i>	1.182	0.429	0.896
	<i>Oreochromisniloticus</i>	1.051	0	0.651
	<i>Tilapia mariae</i>	0	0.429	0.163
	<i>Thyschromisannectens</i>	0.197	0	0.122
	<i>Tilapia guinensis</i>	0.066	0	0.041
	<i>Sarotherodongalileus</i>	0.066	0	0.041
	<i>Parailiapellucida</i>	0	7.503	2.85
	<i>Schilbeintermedius</i>	2.035	0	1.262
Schilbeidae	<i>Schilbemystus</i>	1.182	0.214	0.814
	<i>Pareutropiusbuffei</i>	0	0.107	0.041
	<i>Sardinellamadrensis</i>	2.692	0	1.669
	<i>Pellonulaleonensis</i>	0.788	0	0.489
Clupeidae	<i>Laeviscutelladekimpei</i>	0.131	0	0.081
	<i>Polydactylusquadrifilis</i>	1.379	0.214	0.936
	<i>Elopslarceta</i>	0.591	1.501	0.936
Polynemidae	<i>Polypterussenegalus</i>	0.591	1.393	0.896
Elopidae	<i>Parachanaobscura</i>	0.657	0.965	0.774
Polypteridae	<i>Papyrocranus afar</i>	0.985	0	0.611
Channidae	<i>Xynomystusnigri</i>	0.394	0.107	0.285
Notopteridae	<i>Gymnarchusniloticus</i>	0.525	0.214	0.407
Gymnarchidae	<i>Monodactylussabae</i>	0.46	0.214	0.366
Monodactyliidae	<i>caranx hippos</i>	0.131	0.643	0.326
Carangidae	<i>Heterotisniloticus</i>	0.263	0.322	0.285
Arapaimidae	<i>Brycinuslongipinnis</i>	0.328	0	0.204
Alestidae	<i>Hepsetusodeo</i>	0.131	0	0.081
Hepsetidae	<i>Pomadasysjubelini</i>	0	0.214	0.081
Haemulidae	<i>Dalophisboulengeri</i>	0.131	0	0.081
Ophichthidae	<i>Eucinostomusmelanopterus</i>	0.066	1.393	0.57
Gerreidae	<i>Mlapteruruselectricus</i>	0.066	0	0.041
Malapteruridae	<i>Dagetichthyslakdoensis</i>	0.066	0	0.041
Soleidae	<i>Dormitatorlebretonis</i>	0.066	0	0.041
Eleotridae				

Conclusion and Recommendations

The result of this study has shown that Yewa lagoon has appreciable potential for fisheries exploitation considering its relatively high species composition and abundance. The seasonal variation in fish abundance observed in this study should be considered in future exploitation of the available fish resources in order to match effort with catches. The presence of both fresh and marine water fishes is an indicator that Yewa Lagoon serves as nursery and feeding ground. Alternative fish production practices such as aquaculture programme (pen and cage cultures), artificial introduction of some rare species and practice of closed area and season should be encouraged to boost the fish production in the lagoon. There is also a need for regulatory measures to be put in place to ensure the conservation of the rare species in Yewa Lagoon to avoid their total disappearance.

References

- Ajagbe, F. E. Osibona, A. O and Otitolaju, A.A. (2012). Diversity of the edible fishes of the Lagos Lagoon, Nigeria and the public health concerns based on their Lead (Pb) content. *International Journal of Fisheries and Aquaculture* Vol. 2(3): 55-62.
- Akpan, I. (2013). Species Composition and Abundance in UtaEwa Creek, Niger Delta Region, Nigeria. *Journal of Agriculture and Veterinary Science (IOSR-JAVS)* Volume 3, Issue 3:56-60
- Arome A.G. Ugondo, T.M and Garba, A. (2014). Fish Species Diversity and Abundance of Gubi Dam, Bauchi State of Nigeria. *Asian Journal of Conservation Biology*. Vol. 3(1) 60–67
- Bamidele, N.A., Taiwo, I.O. and Olopade, O.A. 2015. The diversity of Tilapia (Cichlidae) in Yewa Lagoon, Nigeria. *THIKM's 2nd International conference on fisheries and aquaculture*, 25th-26th August 2015, Colombo, Sri Lanka.
- Benech, V., Duran, J.R. and Quensiere, J. (1983). Fish communities of Lake Chad and associated rivers and flood plains. In: Garmuze, J.P., Durand, J.R and Leveque, C. (eds). *Lake Chad, ecology and productivity of a shallow tropical system*. The Hague, 293-356.
- Benson, M.M., Ombogo, M.A., Amadi, J., Baker, N. and Mugalu, D. (2012). Fish Species Composition and Diversity of Small Riverine Ecosystem in the Lake Victoria Basin, Kenya. *International Journal of Science and Technology*. Volume 2 No. 9:1-6
- Bolarinwa J. B., Fasakin, E.A. and Fagbenro A. O. (2015). Species composition and diversity of the coastal waters of Ondo, State, Nigeria. *International Journal of Research in Agricultural and Forestry* Vol.2, No.3:51-58
- Bolarinwa J. B., Okeowo T.O., Fasakin, E.A. and Fagbenro A. O. (2016). The species composition and diversity of the coastal waters of Badagry, Lagos state, Nigeria. *Global Journal of Agricultural Research* Vol.4, No.2:1-6
- Emmanuel, B. E. and Osibona, A. O. (2013). Ichthyofauna characteristics of a tropical low brackish open Lagoon in South-western Nigeria. *International Journal of Fisheries and Aquaculture*. Vol. 5(6):122-135.
- Fagade, S.O. and Olaniyan, C.I.O. (1974). Seasonal distribution of fish fauna of the Lagos Lagoon. *Bull. De IFAN series A36* (1):244-252
- Hammer O., Harper, D.A.T. and Ryan, P.D. (2001). PAST: Palaeontological statistics software packages for education and data analysis. *Palaeontologia Electronic* 4(1):9
- Idodo-Umeh, G. (2003). *Freshwater fishes of Nigeria (Taxonomy, Ecological Notes, Diets and Utilization*. Idodo-Umeh Publishers Limited, Benin city, Nigeria. 232pp
- Udo (2012). Taxonomic composition, Diversity and Abundance of the Ichthyofaunal Assemblage of Iba-Oku stream, Ikpa River, Nigeria. *International Journal of Zoological Research*, 8:71-80

3

Sonification and Its Use in Fishes

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Abstract

Fishes like other vertebrates are able to detect and respond to a wide range of sounds. Sound hearing is based on the detection of the mechanical motions in the medium imparted by the sound. The techniques for determining hearing capabilities of fishes are similar to those used in studies of other animals, or even humans. Teleost fishes produce sound in several ways, none of which involves a larynx or syrinx-like structure as used by terrestrial vertebrates. However, fishes use a variety of different methods to produce sounds that range from moving two bones together to more complex mechanisms involving exceptionally fast muscles connected to the swim bladder. Fishes can produce sounds using three distinctive mechanisms: fast muscles beating on the swim bladder, stridulating bones and hydrodynamics sounds. Sounds produced can either be a long single pulse, a series of rapid short pulse or tones. Fishes produce different types of sounds using different mechanisms and for different reasons and behaviours: aggression, protection of territory, defense, reproduction and in echolocation.

Keywords: Behaviours, Mechanisms, Sonification, Teleost

Introduction

In fish biology sound is a peculiar and significant aspect of their life history (Bortone, 2002). According to him, sounds in fish are closely related to the habitat and as such are given special treatment as a life history attribute. In the summary of Darwin (1874) as reported by (Zahavi, 1975) some species of fish uses sound mechanisms to communicate. This sonic behaviour of many fish species have over the years gone unnoticed (Lobel, 2001). The reasons for the scarce knowledge have been due to the technical difficulties and the cost associated with making quality acoustic recordings underwater. Teleost fish species produce sound in several ways, none of which involves the use of larynx or syrinx-like structure as used by terrestrial vertebrates. However, fishes use variety of methods to produce sounds that range from moving two bones together to more complex mechanisms involving exceptionally fast muscles connected to the swim bladder. In this latter instance, the muscles contract at frequencies high enough to produce sound (Zelick et al., 1999). The gas-filled swim bladder (or gas bladder) in the abdominal cavity may serve as a sound amplifier (although it has other very critical functions as well (Steen, 1970) in (Roberts, 2012). Sounds produced in this way usually have most of their energy below 1,000 Hz. Fishes use sounds in a wide variety of behaviours such as; aggression, protection of territory, defense, and reproduction (Tavolga, 1971; Demski et al., 1973; Zelick et al., 1999). In species of marine catfish (*Arius felis*), a form of sound called echolocation exists. It is the process used to identify objects in its environment by producing low frequency sounds and listening to their reflections (Tavolga, 1976).

Mechanisms of hearing in Fish

Hearing is based on the detection of the mechanical motions in the medium imparted by sound. In fishes, the otolith organs are stimulated directly by the acoustic particle velocity associated with underwater sound fields. In addition Zelick et al. (1999) noted that fish organs can be stimulated indirectly by particle motions created when sound pressure fluctuations are transformed into motion by a gas-filled accessory organ such as the swim bladder. In effect, hearing is based on relative motion between the fish's body and the otolith. The three main ways fishes produce sounds are by using sonic muscles that are located on or near their swim bladder (drumming); striking or rubbing together skeletal components (stridulation); and by quickly changing speed and direction while swimming (hydrodynamics). According to Luczkovich et al. (2008) some fish, such as the sand seatrout (*Cynoscion arenarius*), produce sound by using muscles on or near their swim bladder (also called gas bladder) as shown in Plate 1.

The majority of sounds produced by fishes are of low frequency, typically less than 1000 Hz. Fishes such as drums and croakers (Family Sciaenidae) have sonic muscles attached to or near their swim bladder. These muscles (the fastest contracting muscles known in vertebrates) cause the swim bladder to contract and expand at a rapid rate, thus creating drumming sounds. The majority of sounds produced in this way are short pulses with fundamental frequencies ranging from about 45 - 60 Hz (i.e., goliath grouper and black drum) to about 250 - 300 Hz (i.e.,

toadfish spp. and silver perch). Higher frequency harmonics produced by drumming are sometimes present above 1000 Hz (e.g., silver perch).

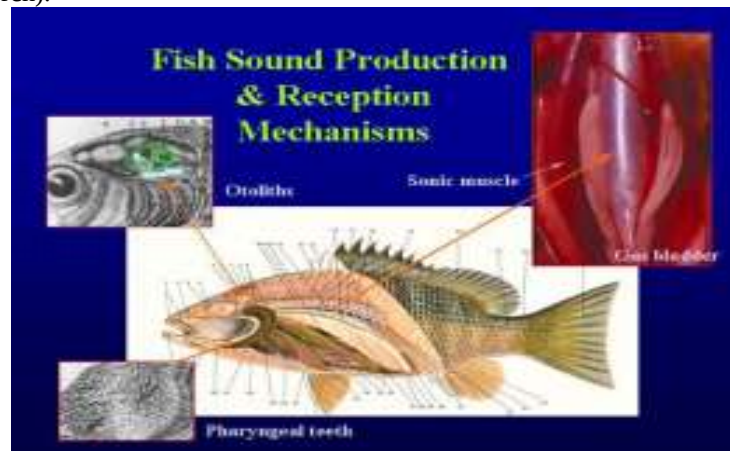


Plate 1: Fish morphology diagram illustrating the sound producing mechanism associated with the gas bladder and sonic muscles in the sand seatrout, *C. arenarius*.

Source: Gilmore Jr.(2002)

Types of hearing in Fish

1. Hydrodynamic Sound

Hydrodynamic sound production occurs when a fish quickly changes direction and/or velocity. These sounds are extremely low frequency. These sounds are simply a by-product of swimming. It is possible that hydrodynamic sounds may be important to predator and prey interactions and communication. For example, it has been postulated that sharks can detect the low frequency hydrodynamic sounds emitted by smaller fishes. Therefore, schooling fishes may inadvertently attract a shark simply by the sounds produced during swimming.

2. Stridulation

Stridulatory sounds are produced when hard skeletal parts or teeth are rubbed together, like the method used by crickets to make sounds. In fishes, stridulation often occurs during feeding when jaw teeth or pharyngeal teeth are gnashed together. Stridulation may be used intentionally to produce sound as a fright response or territorial display. Stridulatory sounds may be modified or amplified by the swim bladder. The component frequencies of stridulatory sounds range from <100 to >8000Hz, while predominant frequencies are generally between 1000 and 4000Hz. Stridulatory sounds influenced by the swim bladder have predominant frequencies well below 1000 Hz (Fine *et al.*, 2001).

Needs for Hearing in Fish

Many fish species are known to produce sounds socially to communicate with other members. Much of this communication has to do with important life history activities such as courting and mating (Hawkins, 1986 and Rountree *et al.*, 2006), feeding and capturing prey, escaping predators or caring for their young. It is becoming clear that although fish may produce sound as warning displays and in feeding, most fish sound is produced to call mates for reproduction. The intensity of sounds produced by mating choruses of male estuarine spotted seatrout and silver perch has been found to be directly proportional to the number of eggs and larvae in the water column. Thus, even though spotted seatrout and silver perch females cannot produce mating calls, they are stimulated enough by male calling activity to mate more often or release more eggs when male call intensity increases (www.fishbase.org). Also it helps fish scientists in identifying various species of fish (fish identification). More so, the discovery of specific mating sound has important application to the development of applied fisheries technology for mapping fish spawning sites.

Conclusion

This review focused on sound production in some fishes with emphasis on the mechanism processes, the types of sounds produced and its importance to fish survival. Basically, sound can be produced through motion between the fish's body and the otolith. This can be through the use of sonic muscles that are located on or near their swim bladder (drumming); striking or rubbing together skeletal components (stridulation); and by quickly changing speed

and direction while swimming (hydrodynamics). The major need for sonification is for procreation that is the attraction of opposite sex and mating. It is also of great importance in feeding, capturing prey, escaping predators and as warning display.

References

- Bortone, S. A. (Ed.). (2002). *Biology of the spotted seatrout*. CRC press.
- Demski, L., Gerald, G. W., and Popper, A. N. (1973). Central and peripheral mechanisms in teleost sound production. *Animal Zoology*, 13, 1141-1167.
- Fine, M.L., Malloy, K.L., King, C.B., Mitchell, S.L. and Cameron, T.M. (2001). Movement and sound generation by the toadfish swim bladder. *Journal of Comparative Physiology A* 187: 37.
- Gilmore Jr, R. G. (2002). Sound production and communication in the spotted seatrout. In *Biology of the spotted seatrout* (pp. 191-210). CRC Press.
- Hawkins, A. D. (1986). Underwater sound and fish behaviour. Pages 114–151 in T. J. Pitcher, editor. *The behaviour of teleost fishes*. Groom Helm, London
- Lobel, P. S. (2001). Fish bioacoustics and behavior: passive acoustic detection and the application of a closed-circuit rebreather for field study. *Marine Technology Society Journal*, 35(2), 19-28.
- Luczkovich, J. J., Mann, D. A., and Rountree, R. A. (2008). Passive acoustics as a tool in fisheries science. *Transactions of the American Fisheries Society*, 137(2), 533-541.
- Roberts, R. J. (2012). *Fish pathology*. John Wiley & Sons.
- Rountree, R. A., R. G. Gilmore, C. A. Goudey, A. D. Hawkins, J. Luczkovich, and D. Mann. 2006. Listening to fish: applications of passive acoustics to fisheries science. *Fisherie*, 31:433–446.
- Tavolga, W.N. (1962). Mechanisms of sound production in the ariid catfishes *Galeichthys* and *Bagre*. *Bulletin of the American Museum of Natural History*, 124, article 1.
- Zahavi, A. (1975). Mate selection—a selection for a handicap. *Journal of theoretical Biology*, 53(1), 205-214.
- Zelick, R., Mann, D. A., and Popper, A. N. (1999). Acoustic communication in fishes and frogs. In *Comparative hearing: fish and amphibians* (pp. 363-411). Springer, New York, NY.

4

Length-Weight Relationship and Condition Factor of the Silver Catfish *Chrysichthys nigrodigitatus* (Lacepède, 1803) From the Great Kwa River, Cross River State, Nigeria

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Abstract

This study was carried out to evaluate the length-weight relationship, growth pattern and condition factor of the Silver Catfish *Chrysichthys nigrodigitatus* from the Great kwa River, Cross River, Nigeria. A total of 100 freshly caught specimens of *C. nigrodigitatus* were collected between July 2018 and September 2018 from the catches of the fish landing of Artisanal fishermen at Unical beach (Esuk Atu). Results obtained showed that the “b” value for the males was 1.6067 while that of the females was 1.6791 and combined sexes 1.7371, indicating a negative allometric growth for this species. Correlation coefficient (r) obtained for males (0.9651), 0.9517 (females) and 0.9329 (pooled sexes) showed a positive significant relationship between length and weight of *C. nigrodigitatus*. Monthly mean condition factor (K), indicate that *C. nigrodigitatus* were in good physiological health condition. In conclusion, the baseline data on the length-weight relationship, condition factor of *C. nigrodigitatus* from the Great Kwa River provided in this study is crucial in the sustainable management of this species in the River. Also, these findings will be useful in evaluating the growth pattern, health status and the aquaculture potential of *C. nigrodigitatus* in the Great kwa River.

Keywords: Growth pattern; *Chrysichthys nigrodigitatus*; Condition factor; Length-weight relationship

Introduction

The silver catfish *Chrysichthys nigrodigitatus* (Lacepède, 1803) is a popular food fish that is widely distributed among tropical rivers and freshwater lakes of Western and Central Africa (Adite et al., 2006). *Chrysichthys nigrodigitatus* is an important food fish to the inhabitants of the Cross River because of its protein content, good taste and high meat quality (Eyo et al., 2013). Due to the intensification of the capture of this species to meet the demand by consumers, its population has declined in the study area. Little or no attention is paid to its declining population due to scarcity of crucial information such as its biology which could in making managerial decisions for *C. nigrodigitatus* fishery and its aquaculture potentials. There are indications of decline in catch of fishes of commercial importance qualitatively and quantitatively in both coastal and inland water systems due to overexploitation and environmental degradation (Jamu and Ayinla 2003). Studies on the aspects of biology of fin fishes such as growth pattern, reproduction, nutrition are necessary as they would furnish relevant information for the formulation of fisheries management policies. Therefore, the objective of this study is to evaluate the length-weight relationship, growth pattern and condition factor of the Silver Catfish *C. nigrodigitatus* from the Great kwa River which will be used in formulating sustainable management of this species.

Materials and Methods

Study Area

The study area of this research is the Great Kwa River (one of the major tributaries of the Cross River Estuary) located in Calabar, Cross River State. Great Kwa River is located between latitudes 4°45' and 5°15' N and longitudes 8°15' and 8°30' E. The climate of the area is tropical.

Sampling Regime

Samples of *C. nigrodigitatus* were collected once a month for three months from July to September 2018. A total of one hundred (100) *C. nigrodigitatus* was collected from fish landing of Artisanal fishermen at Unical beach (Esuk Atu).

Measurements of Biometric Indices

Biometric parameters measured for each specimen were Total length (TL-cm) and Total weight (TW-g). Total length (TL-cm) was measured using from the tip of the mouth to the end of the caudal fin to nearest 0.1 cm using measuring board. Total weight (TW-g) was measured to the nearest 0.1 g using Metlar-2000D electronic weighing balance. The sex of each specimen was also determined to separate males from females. Measurements, sex determination and condition factor were carried out in the laboratory.

Length-Weight Relationship

Length weight relationship of *C. nigrodigitatus* from the Great Kwa River was estimated using

Pauly (1983) equation as follows:

$$W = aL^b$$

Where W is the total weight of the fish in grams, L is the total length of the fish in centimeter, 'a' is the intercept and 'b' the growth exponent.

A logarithm transformation given below was used to obtain a linear relationship.

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

Condition Factor (K)

Fulton's condition factor (K) of *C. nigrodigitatus* was calculated using Pauly (1983) equation, $K = W/L^3 \times 100$, where W is the total weight of the fish in grams, L is the total length of the fish in centimeter and 3 is a constant.

Statistical Analysis

Values of regression coefficient 'b' intercept 'a' and coefficient of correlation 'r' in Length-Weight relationship (LWR) of *C. nigrodigitatus* from the Great Kwa River were determined by linear and power regressions. The condition factor was subjected to One Way Analysis of Variance to determine if there is any significant difference between the male, female and pooled sex of *C. nigrodigitatus*.

Results and Discussion

The length-weight relationship and correlation coefficient (r) for male, female and pooled sex of *C. nigrodigitatus* from the Great Kwa River were logarithmically transformed as depicted in Figs. 3-5. The value of 'b' for the male was 1.6067 while that of the female was 1.6791, for combined sexes the value was 1.7371. The correlation coefficients (r) were 0.9651, 0.9517 and 0.9329 for male, female and combined sexes respectively.

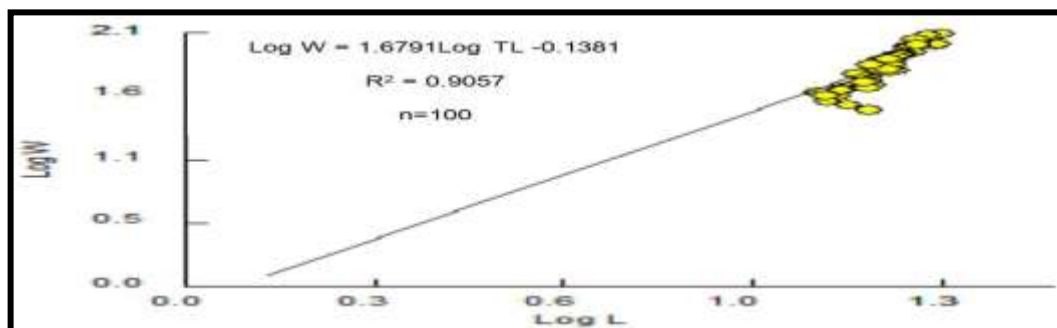


Fig. 1: Length-weight relationship of male *C. nigrodigitatus* obtained from Great Kwa River

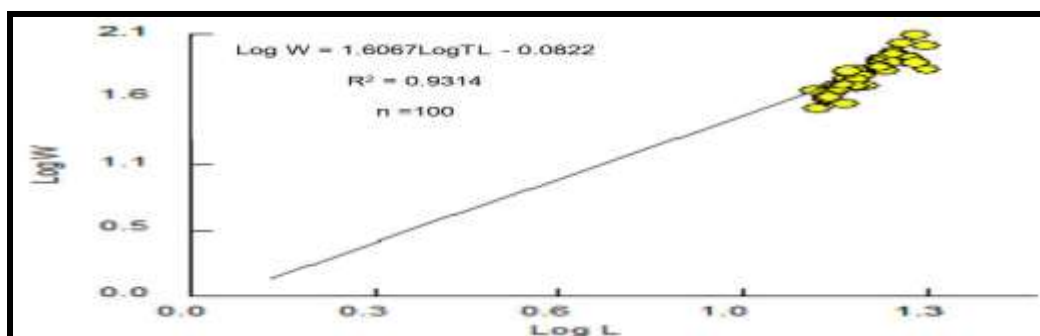


Fig. 4. Length-weight relationship of Female *C. nigrodigitatus* obtained from Great Kwa River

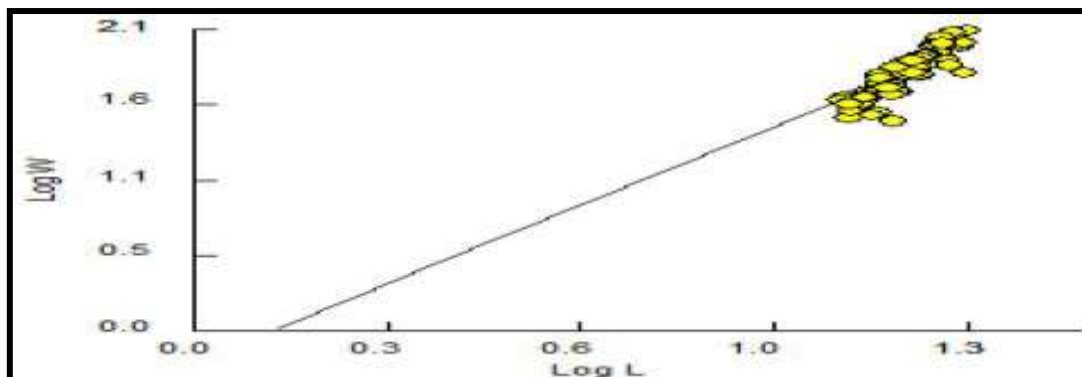


Fig. 5. Length-weight relationship of combined sexes *C. nigrodigitatus* obtained from Great Kwa River

Table 1: The Monthly Mean Condition Factor of *C. nigrodigitatus* from Great Kwa River

Months	Male	Female	Pooled Sex Data
July	2.10 ± 0.06 ^a	2.11 ± 0.05 ^a	2.09 ± 0.03 ^a
August	1.21 ± 0.07 ^a	1.87 ± 0.06 ^b	1.81 ± 0.05 ^c
September	1.78 ± 0.06 ^a	1.81 ± 0.09 ^b	1.97 ± 0.04 ^c

Fulton's condition factor (K) determined for two hundred (200) specimens of *C. nigrodigitatus* (Table 1) showed that mean condition factor of male and female *C. nigrodigitatus* in July was 2.10 ± 0.06 and 2.11 ± 0.05; August was 1.21 ± 0.07 and 1.87 ± 0.06 while September was 1.78 ± 0.06 and 1.81 ± 0.09 respectively. For pooled sex of *C. nigrodigitatus*, condition factor was 2.09 ± 0.03 (July), 1.81 ± 0.05 (August) and 1.95 ± 0.04 (September). The 'b' value obtained in this study is similar to results obtained from Ogamba et al. 2014 who reported a negative allometric growth pattern ($b = 0.0536$) for *C. nigrodigitatus* collected from Odi River, Niger Delta, Nigeria. Also, a similar finding was reported by Uneke (2013) from Ebonyi River, South Eastern Nigeria. According to Eyo et al., (2015), fish exhibiting a negative allometric growth pattern tends to become thinner as they increase in length. Findings of this study agrees with findings of Edem et al., (2018) who reported a negative allometric growth pattern function from lower River Benue. According to Lagler et al. (1997), such variations in growth parameters documented for different fish species could be attributed to sex, maturity, developmental stage, season and harsh environmental conditions. Froese (2006) opined that length-weight parameters of fish are influenced by both intrinsic and extrinsic factors such as diet, season, stomach fullness, health, preservation techniques, habitat, sex, gonad maturity and annual variation in environmental conditions. Also, "b" value in fish can be affected by sample size, habitat suitability, fishing activities, individual metabolism, age and maturity (Hossain, 2010). In this study, a positive significant ($P < 0.05$) correlation coefficient (r) obtained for *C. nigrodigitatus* (0.965, 0.952 and 0.933) indicates a strong association between the total length and total weight of the fish (Andem et al., 2011). Condition factor is an important index used in fisheries science to ascertain the relative wellbeing of fish species. Condition factor which could be used to reflect the health status of water bodies is influenced by factors such as age, sex, food availability, and environmental conditions. Low condition factor in fish may be attributed to poor environmental conditions and

reduced availability of food and prey items Abowei and Hart 2009) and Edem et al., (2018). Findings of this study shows that *C. nigrodigitatus* in the Great Kwa River was in a better condition which could be attributed to availability of food.

Conclusion

Length-weight relationship and condition factor of *C. nigrodigitatus* from the Great Kwa River provided in this study is crucial in the sustainable management of this species in the River. Also, these findings will be useful in evaluating the population dynamics, stock and the aquaculture potential of *C. nigrodigitatus* for future purpose.

References

- Abowei, J. F. N. & Hart, A. I. (2009). Some morphometric parameters of ten fin-fish species from the lower Nun River, Niger Delta, Nigeria. *Medwell Journals (Pakistan). Research Journal of Biological Sciences*, 4(3): 282-288.
- Adite, A., Winemiller, K.O, Fiogbe, E. D. (2006). Population structure and reproduction of the African bonytongue Silver Catfish in the So River-floodplain system (West Africa): implications for management. *Ecology of Freshwater Fishes*;15:30-39.
- Andem, A. B, George, U. U. & Eyo, V. O. (2011). Length Frequency Distribution of (*Chrysichthys nigrodigitatus*) (Lecepede, 1803) (*Chrysichthys*, Bagridae) from Itu Head Brigde, in Akwa Ibom State, Nigeria. *International Journal of Science and Research*, 2(9):258–260.
- Asuquo, P. E, Eyo, V. O., Ikechukwu, C. C. (2015). Feeding Ecology, Length-Weight relationship and Condition Factor of *Mugil cephalus* (Pisces: Mugilidae; Linnaeus, 1758) From Cross River Estuary, Nigeria. *European Academic Research*, 2(12):15276–15294.
- Edem, E. T., Ofunama, P. & Eyo, V. O. (2018). Length-weight Relationship, Growth Pattern and Condition Factor of the Silver Catfish (*Chrysichthys nigrodigitatus*) (Lacepède, 1803) from Lower River Benue, Nigeria. *Asian Journal of Fisheries and Aquatic Research*, 1(2): 1-8.
- Eyo, V. O., Ekanem, A. P., Eni, G. E., Asikpo, P. E. & Jimmy, U. (2013). Relationship between fecundity and biometric indices of the Silver Catfish *Chrysichthys nigrodigitatus* (Lacepede) in the Cross River estuary, Nigeria. *Croatian Journal of Fisheries*, 83-92.
- Eyo, V. O., Akpan, M. M. & Udoh, I. S. (2015). Some aspects of the biology of the female blue crab *Callinectes amnicola* from the Cross River estuary, Nigeria. *European Academic Research*, 11(12):15277-15294.
- Froese, R. (2006). Cube law, condition factor and weight-length relationships: History, meta analysis and recommendations. *Journal of Applied Ichthyology*, 22:241-253.
- Hossain, M. Y. (2010). Morphometric relationships of length-weight and length-length of four Cyprinid small indigenous fish species from the Padma River (NW Bangladesh). *Turkish Journal of Fisheries and Aquatic Science*, 10:131-134.
- Jamu, D. M. & Ayinla, O. A. (2003). Potential for the development of Aquaculture in Africa. *Naga, worldfish center Quarterly*, 26(3), pp.9-13.
- Khairnazam, M. Z. & Norma-Rashid, Y. (2002). Length–Weight relationship of mudskippers (Gobiidae: Oxudercinae) in the coastal areas of Sclangor, Malaysia. *International Centre for living Aquatic Resources Management, WorldFish Centre Quarterly*, 25:20-22.
- Lagler, K. F., Bardack, J. E., Miller, R. R. & Passino, D. R. M. (1997). *Ichthyology* 2nd Edition, John Willey and Sons, New York. 506p.
- Ndome, C. B., Eteng, A. O. & Ekanem, A. P. (2012). Length-weight relationship and condition factor of the smooth mouth marine catfish (*Carlarius heudelotii*) in the gulf of Guinea, Niger delta, Nigeria. *AACL Bioflux*, 5(3):163-167.
- Ogamba, E. N., Abowei, J. F. N. & Onugu, A. (2014). Length -weight relationship and condition factor of selected finfish species from Odi River, Niger Delta, Nigeria. *Journal of Aquatic Science*, 29(1A):1-12.
- Pauly, D. (1983). Some simple methods for the assessment of tropical fish stock. *FAO Fish. Tech. Pap. No. 234*. 1983;52.
- Thomas, J., Venus, S. & Kurup, B. M. (2003). Length- Weight relationship of some deep sea fishes inhabiting the continental slope beyond 250m depth along west coast of India. *Naga. ICLARM Quarterly*, 26:17-21.
- Uneke, B. I. (2013). Morphometric parameters and condition factor of *Tilapia zilli* (Perciformes: Cichlidae) of the Mid Cross river flood system, South Eastern Nigeria. *Continental Journal of Animal and Veterinary Research*, 6(1):1-10.

5

Heavy Metals Concentration in Pink Shrimp (*Penaeus notialis*) From Ijora Fish Market, Lagos State, Nigeria

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Abstract

Heavy metals are pollutants of the aquatic environment because of their toxicity, persistency, non-biodegradable and tendency to accumulate in organisms. This study is aimed at monitoring the heavy metals concentrations in the muscle of the Pink Shrimps (*P. notialis*) sold at Ijora fish market in Lagos State. This heavy metal concentration was analysed using a scientific flame atomic absorption spectrophotometer (AAS). The mean concentration of zinc (Zn), copper (Cu), cadmium (Cd), chromium (Cr), iron (Fe), nickel (Ni), manganese (Mn), lead (Pb) and cobalt (Co) in *P. notialis* were determined. Zn, Cu, Cr, Fe and Ni were 14.1, 4.91, 2.62, 10.6, 1.49 mg/kg respectively. While Cd, Mn, Pb and Co were found considerably below the detection limit (BDL). In comparison with FAO/WHO, Zn, Cu, Fe and Ni were above the maximum permissible limits as recommended by the Food and Agriculture Organization (FAO) and World Health Organization (WHO), for heavy metals in seafood. This indicates risk for human consumption, so the need for continuous monitoring.

Keywords: Concentration, Heavy Metals, Ijora market, *Penaeus notialis*,

Introduction

The increasing use of heavy metals in the industry has led to an increase in the release of harmful heavy metals into the aquatic environment (Oguguah and Ikegwu, 2017). The heavy metals are accumulated in the marine environment and then transferred to marine organisms. Due to industrialization and agricultural production, most water bodies that serve as the source of these shrimps most especially in developing countries are continuously been contaminated with the heavy metal release (Oluyemi and Olabanji et al., 2011). Hence the threat of metal toxicity to the ecosystem and human population is of great concern (Abubakar et al., 2014). Shrimp (*P. notialis*), rich in protein, minerals, vitamins, antioxidants, essential amino acids and unsaturated fatty acids (Williams et al., 2013) is considered as one of the most beneficial shellfish ailments for human consumption. *P. notialis* (Pink shrimps) are benthic feeders since they constitute an important human food, they are potentially an indirect source of metals entering the body.

However, shrimps have been reported to bioaccumulate heavy metals much higher than the level present in the water bodies and sediments (Abubakar et al., 2014). Chindah et al. (2004) reported that shrimps have the tendency to bioaccumulate certain heavy metals in the environment than others and further suggested that they can be used as possible bioaccumulator or bioindicators for heavy metal pollution monitoring programmes. Some heavy metals such as cobalt (Co), manganese (Mn), zinc (Zn) and iron (Fe) are essential to maintain body metabolism. Although some metals are essential for living organisms, some are highly toxic or become toxic at high concentrations. Metals such as lead (Pb), nickel (Ni), cadmium (Cd) and chromium (Cr) are not generally required for metabolic activities (Biswas et al., 2021). Attaining shrimp safety in developing countries entails the assessment of parameters that determines their level of consumption (Omobepade et al., 2020). This study was therefore carried out to determine the concentration of some heavy metals in *P. notialis* sold at the Ijora fishmarket.

Materials and Methods

Sample Collection and Preparation

Pink shrimp (*P. notialis*) were purchased at the Ijora fish market. The shrimp samples were placed in a pre-washed polythene bag and taken in an ice-cold box before being transported to the laboratory for analysis.

Reagent/apparatus: All reagents used were of analytical grade. Distilled water was used for solution preparation and dilutions. All glasses were soaked in 10% HNO₃ for 24hrs and later rinsed with distilled water before use for heavy metal analysis.

analysis of heavy metals: The wet method of digestion was used to carry out the sample digestion.

Exactly 5.0g of the homogenized samples were weighed and digested with 25ml 6N HNO₃. The digested sample was analysed for zinc (Zn), copper (Cu), cadmium (Cd), chromium (Cr), iron (Fe), nickel (Ni), manganese (Mn), lead (Pb) and cobalt (Co) using scientific flame atomic absorption spectrophotometer (Varian spectrophotometer AA 600 model).

Results

The results of the mean concentrations of the heavy metals in the *P. notialis* samples are shown in Table 1. The concentrations of heavy metals were Zn, 14.1 mg/kg Cu 4.91 mg/kg, Cr 2.62 mg/kg, Fe 10.6 mg/kg and Ni 1.49 mg/kg. While Cd, Mn, Pb and Co were below the detection limit (BDL).

Table 1. Mean heavy metals concentration (mg/kg) in *P. notialis* from the Ijora market

Heavy Metals	Concentration (mg/kg)	Permissible Limit (FAO/WHO)
Zn	14.1	0.3 – 1.0
Cu	4.91	0.4
Cd	BDL	0.03
Cr	2.62	2.3
Fe	10.6	4.0
Ni	1.49	0.6
Mn	BDL	2.5
Pb	BDL	0.3
Co	BDL	0.015

BDL means Below Detection limit
WHO/FAO (1989)

Discussion

The values of the heavy metal concentrations determined in *P. notialis* purchased from the Ijora fish market shown in this study are presented as Zn > Fe > Cu > Cr > Ni. This variation might be due to the level of bioaccumulation, which is a function of species, pH, temperature and trophic transfer (Oguguah and Ikegwu, 2017). The consumption of these metals in excess could impact health hazards to humans. Metals such as Cd, Mn, Pb and Co were found considerably below the detection limit. Zn is an essential element in the human diet and it is required to maintain the functioning of the immune system (Dhanakumar et al., 2015) however, a high concentration of zinc may lead to nausea, vomiting, renal damage, cramps e.t.c. Zinc concentration was found at a very high concentration when compared with the permissible limit by FAO/WHO (2012). Iron is an essential element for biological functions but in excess is related to heart disease, cancer e.t.c. A high level of Fe (10.6 mg/kg) was determined similar to work by Williams et al. (2013) where copper (Cu) level was high (4.91 mg/kg). Cu is essential to human life as metalloproteins and functions as enzymes. However, elevated doses lead to health risks such as anaemia, kidney and liver dysfunction (Lokeshappa et al., 2012). Cr mean concentration was reported to be 2.62 mg/kg. Cr is known to help maintain normal blood glucose levels by enhancing the effects of insulin (Dhanakumar et al., 2015). Cadmium (Cd) concentration was below the detection limit, which means that the seafood is safe for human consumption as the recommended amount by FAO /WHO. Mn level was good and is a known essential micronutrient for many biochemical reactions in living beings (Dhanakumar et al., 2015). Pb and Co were also below the detection limit.

Conclusion

This study showed that Zn, Cu, Fe and Ni were present in the *P. notialis* at a concentration above the regulatory standard (WHO/FAO) which indicate risk for human consumption. Therefore, there is a need for regular monitoring of heavy metals concentrations in shrimps so that human health is not at risk.

References

- Abubakar, A. U., Ekwumemgbo, P. A. and Okunola O. J. (2014). Evaluation of Heavy Metals concentration in imported Frozen Fish *TrachurusMurphyi* species sold in Zaria Market, Nigeria. American Journal of Chemistry 4(5): 137 – 154.
- Biswas C, Sarmin S.S., Rohani, F., Rahman, H., Bashar, A. and Hussain, S. (2021) Assessment of heavy metals in farmed shrimp, *Penaeus monodon* sampled from Khulna, Bangladesh: An inimical to food safety aspects. Department of Aquaculture, Bangladesh Agricultural University, Heliyon7.
- Chindah, A. C., Braide, A. S. and Sibeudu, O. C. (2004): Crustacean (shrimps –*Penaeus notialis*) from the Bonny/New Calabar River Estuary, Niger Delta, AJEAM-RAGEE Volume 9, page 1 – 17.

- Dhanakumar, S. Solaraj, G. and Mohanraj, R. (2015) Heavy metal partitioning in sediments and bioaccumulation in commercial fish species of three major reservoirs of river Cauvery delta region, India. *EcotoxicolEnvrion Safety*, 113:145-151.
- FAO/WHO (1989). "WHO technical report series No. 505, Evaluation of certain food additives and the contaminants mercury, lead and cadmium for environment monitory report No 52 centres for the environment." Tech. Rep. Fisheries and Aquaculture Science lowest TofitUk.
- Lokeshappa, B. O., Shivpuri, K, Tripathi, V and Dikshit, A. K. (2012). Assessment of Toxic Metals in Agricultural Produce, Food and Public Health, 2(i): 24 – 29.
- Oguguah N. M and Ikegwu M. O. J. (2017). Concentration and Human Health Implications of Trace Metals in fish of Economic Importance in Lagos Lagoon, Nigeria. *J Health Pollution* 13:66-72.
- Oluyemi, E. A and Olabnji I. O. (2011). Heavy metals determination in some species of frozen fish sold at Ile-Ife main market, Ife Journal of Science, 13, (2):86-93.
- Omobepade, B.P., Akinsorotan, A.M., Ajibare, A.O., Ogunbusola, E.M, Ariyomo, T.O., Jimoh, J.O. Odeyemi, K.M., Okeke, O.S., Falabake, M.A., Adeniji S.M. and Adedapo A.M. (2020) Heavy Metal concentration in white shrimp *Nematopalamon status* and their Association Ecological and Health Risk in the Nigerian Continental Shelf. *Egyptian Journal of Aquatic Biology of Fisheries* Vol24 (2):301 – 316.
- Williams K. N., Wegwu, O.W. and Essien E. B. (2013). Heavy metals concentrations in four selected seafood from crude oil-polluted waters of Ogoni land, RiversState, Niger. *Archives of Applied Science Research* 5(4); 97-104.

6

Toxicity Effect of Marijuana (*Cannabis sativa*) Leaf Extract on *Clarias gariepinus* Fingerlings

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Abstract

This study investigated the toxicity effect of *Cannabis sativa* on fingerlings of African catfish (*Clarias gariepinus*) exposed to sub lethal concentrations of *C.sativa* leaf extract. The fingerlings were exposed to treatments (T₁, T₂, T₃ and T₄) in g/l over a period of 96 hours. Phytochemical analysis on the powdered leaf extract showed the presence of most important metabolites like alkaloids, flavanoids, phytosteroids, quinone, cardiac glycosides which proved its toxicity to fish. The median lethal concentration (LC₅₀) value of *C.sativa* was -44g/l for 96 hours exposure. Prior to death, fish exhibited marked behavioural changes like aggressiveness, erratic movement, jumping, air gasping, stunned position and settling at the bottom which revealed sensitive indicators of physiological stress in fish. This study revealed that *C.sativa* leaf extract is a potential aquatic toxicant as evident in its deleterious effect on the behavioural profile and cumulated stressed condition in *C.gariepinus* fingerlings.

Keywords: Toxicity, behavioural profile, LC₅₀, *Cannabis sativa* and *Clarias gariepinus*.

Introduction

Clarias gariepinus is one of the most commercial food fish and cheap source of animal protein in Africa (USAID Markets, 2010). The catfish is widely cultured throughout Africa in both natural and artificial habitats (Nguyen and Janssen, 2002), (Adeyemo, 2008). Owing to its fast growth rate and superior tolerance to deranged water quality, it remains the choice fish for research in aquatic ecotoxicity (Mahmoud *et al.*, 2009). Piscicidal plants are those plants that when touched or ingested in sufficient quantity can be harmful or fatal to fishes (Egeruoh, *et al.*, 2015). Piscicidal plants are frequently used by fisher folk of various Africa countries extensively for capturing fish and reported to be of high potency (Fafioye, 2001 and Fafioye *et al.*, 2004). Phytochemical analysis of *C.sativa* revealed varied proportions of some bioactive substances such as alkaloids, flavonoids, steroids and phytosteroids, coumarines, Quinone and cardiac glycosides (Egeruoh *et al.*, 2019).

The acute toxicity of pesticides of fish has involved the determination of the LC₅₀, which is the concentration that kill 50% of group of fish under specified conditions (Lloyd, 1972). The Lethal concentration (LC₅₀) of the piscicidal (*C. sativa*) leaf extract will be determined by subjecting the result to probit and logit analyses. Acute toxicity concentration of cymbush pesticides on fingerlings of *C. gariepinus* resulted in dark skin patches, slow opercula beats, respiratory stress, erratic swimming and death (Angugwo, 2002). This study was under taken to determine the median lethal concentration and haematological effect of *C.sativa* leaf extracts on *Clarias gariepinus* fingerlings.

Materials and Methods

Collection and preparation of experimental plant *Cannabis sativa* (Marijuana)

Leaves of *Cannabis sativa* (marijuana) were obtained from Delta State, Nigeria. The leaves were carefully sorted out by handpicking, shade-dried at ambient temperature and milled into fine particle size and sieved with 250µm mesh size net, and kept in a dry, clean, air-tight transparent plastic container.

Phytochemical Screening for active ingredients

Phytochemical screening was carried out on the leaf extract of *C.sativa* to detect the presence of alkaloids, flavonoids, steroids and phytosteroids, coumarines, Quinone and cardiac glycosides. Phytochemical examination by (Vijayalakshmi and Ravindrann, 2012) were used for the screening.

Collection and Acclimatization of Experimental Fish (*C.gariepinus*.) Fingerlings

A total of 200 fingerlings of *C.gariepinus* (21.26 ± 0.2g mean weight; mean ± SEM and 14.4 ± 0.10 cm mean total length; mean ± SEM) were purchased from commercial farm (Perez farm and fisheries Owerri) Imo State, Nigeria.

The fish were transported in oxygenated bags to the Biology research laboratory, Alvan Ikoku Federal College of Education, Owerri Imo State. They were kept in glass aquaria tanks of 40 x 40 x 20cm where they were acclimatized to laboratory conditions for fourteen days prior to exposure period. They were fed at 5% body weight daily with 3mm catfish feed formulated in the laboratory and the experimental water changed every other day. Feeding was stopped 48 hours before and throughout the 96 hours experimental period (Adeyemo, 2005) in order to minimize interference by the stomach contents and wastes from exposed fish (Ayotunde and Ofem, 2008; Olufayo, 2009), to minimize the amount of waste in the test media decomposition and oxygen depletion. After the acclimation period, the fish were randomly selected and stocked 10 fish per bowl in 5 bowls for each of the experimental leaf extract.

Water Quality Parameters

The water quality parameters of the various experimental media were monitored every 24 hours. The parameters determined were:

- i. Temperature ($^{\circ}\text{C}$)
- ii. PH
- iii. Dissolved oxygen (mg/l)
- iv. Total alkalinity (mg/l)

Toxicity testing

Fish from different container with different concentration of marijuana leaf extract were randomly selected and used for further toxicological experimentation. The Lethal Concentration (LC_{50}) for the leaf *C.sativa* leaf extract over the entire 96hours exposure period was determined by subjecting results to probit and logit analyses (Finney,1971). The level of toxicity of the leaf extract was determined based on hazard rating for synthetic agrochemicals (Louis *et al.*, 1996). The maximum admissible toxicant concentrations for the extract were established for *C.gariepinus* fingerlings by multiplying the estimated 96h LC_{50} by a constant 0.01-0.1(Koesoemadinata 2000). Fish were considered dead when the opercula and tail movements stopped and there was no response to a gentle prodding. Dead fish were removed immediately from test solutions to avoid fouling the test media.Data was subjected to analysis of variance (ANOVA).

Results

Phytochemical screening of the leaf extract of marijuana showed the presence of most important phytoconstituents. The extracts contains metabolites like alkaloids, flavanoids, phytosteroids, quinone, cardiac glycosides and somemetabolites like glycosides, phenols, terpenoids, phlobatannins, anthraquinones were not confirmed as presented in Table 1.

Table 1: Qualitative phytochemical analysis of *C.sativa* leaf extract

Phytochemicals	Quality <i>C.sativa</i>	Test
Alkaloids	+++	Mayer's test
Tannins	-	Ferric chloride test
Flavanoids	+++	Ammonium hydroxide test
Saponins	-	Distilled water test
Steroids & Phytosteroids	+++	Conc. Suphuric acid test
Phenols	-	Lead acetate test
Coumarines	+++	NaOH test
Quinone	+++	Conc. Suphuric acid test
Cardiac glycosides	+++	Keller-killani test

Keys: - = Absent, + = Mild
++ = Moderate, +++ = strong

Water Quality Parameters

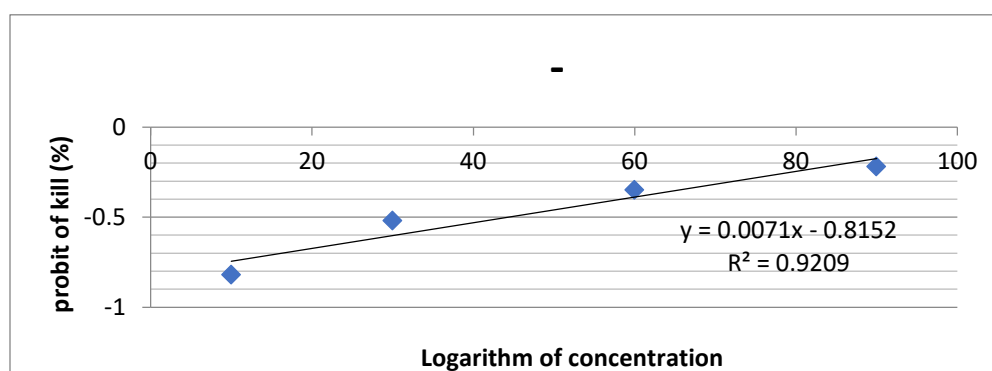
The mean water quality parameters measured during the 96hrs period are presented in Table 2 showed no significant difference ($P < 0.005$) in the temperature of all the treatments including T_0 . As the concentration of the extract increases, the pH and dissolved oxygen decreases insignificantly ranging from 6.6 to 6.0 and 4.5 to 4.0, while T_0 recorded 7.0 and 4.5 respectively.. Alkalinity increases as concentration increases ranging from 12.38 to 14.40mg/l.

Table 2: Mean values ($\pm$ SE) of water quality parameters of different concentrations of *C.sativa* leaf extract on *C.gariepinus* fingerlings

Treatments in g/l					
Parameters	T ₀	T ₁	T ₂	T ₃	T ₄
Temperature(⁰ C)	22.3 $\pm$ 0.0	22.4 $\pm$ 0.1	22.4 $\pm$ 0.1	22.4 $\pm$ 0.1	22.4 $\pm$ 0.1
pH	7.00 $\pm$ 0.00	6.60 $\pm$ 0.20	6.30 $\pm$ 0.40	6.37 $\pm$ 0.15	6.01 $\pm$ 0.45
Dissolved oxygen(mg/l)	4.50 $\pm$ 0.00	4.50 $\pm$ 0.20	4.30 $\pm$ 0.22	4.10 $\pm$ 0.22	4.00 $\pm$ 0.21
Alkalinity(mg/l)	10.25 $\pm$ 1.50	12.38 $\pm$ 1.50	12.82 $\pm$ 1.60	14.02 $\pm$ 2.00	14.40 $\pm$ 0.00

Median lethal concentration (LC₅₀)

The LC₅₀ values of this test were obtained by the use of two variables to determine the most suitable range for LC₅₀ within a specified period of 96hours, through certain established values in the probability table and the corresponding figures in the logarithm. Here, the concentration values were converted to logarithm numbers while the specific mortality rates were derived from the already corresponding probability table.

**Fig 1: Linear relationship between probit value and logarithm concentration of *C.sativa* leaf extract to which *C.gariepinus* fingerlings was exposed during 96 hours exposure period.**

The acute toxicity test of *C.gariepinus* fingerlings exposed to leaf extract concentrations of marijuana (*C.sativa*) showed mortality of 90%, 60%, 30% and 10% in the T₄, T₃, T₂ and T₁ respectively. No mortality was recorded in T₀. The LC₅₀ of the various leaf extract concentrations of marijuana exposed to *C. gariepinus* fingerlings during the 96% hours period was -44g/l with line of best fit equation: $y = 0.007x - 0.815$ and R^2 value of 0.920. Regression analysis implies that mortality rate of the test fish and concentrations of leaf extract of *C.sativa* are positively correlated. It implies that mortality rate of the fish increased with increase in the concentrations of the leaf extract.

Behavioural studies

Observations on the agitated behavioural pattern and respiratory distress rate on *C.gariepinus* fingerlings exposed to the leaf extract of *C.sativa* was as shown in Table 3. Agitated behaviour and respiratory distress increased with exposure period for the leaf extract, except for vertical positioning, air gasping and stunned posture that continued and increased with exposure period. The fishes showed erratic movement and loss of equilibrium as concentration increases. After 24hrs, mortality occurred in T₂, T₃ and T₄ of *C.sativa* leaf extracts while fishes in the T₀ exhibited no unusual signs nor died throughout the exposure period. The fish that died are confirmed dead when it showed no response on pushing the experimental bowl gently, floating with side and change of colour to white and skin looks like its peeling. The number of mortality were recorded and dead ones were removed from the bowl to avoid contamination of the water. The fingerlings exposed to T₃ and T₄ extract of *C.sativa* showed high mortality rate and none died in the T₀.

Table 3: Agitated behavioural pattern and respiratory distress rate of *C.gariepinus* fingerlings exposed to leaf extract of *C.sativa*.

Activities	Treatments				
	T ₀	T ₁	T ₂	T ₃	T ₄
Aggressiveness	-	-	+	++	+++
Erratic movement	-	-	-	+	++
Jumping	-	-	+	++	+++
Stunned position	-	+	++	+++	+++
Rapid opercula movement	-	+	++	++	+++
Vertical position	-	+	++	++	+++
Air gasping	-	-	+	++	+++
Death	-	-	+	++	+++

Keys: - = None, + = Weak, ++ = Moderate, +++ = Strong

Discussion

This study revealed that fingerlings exposed to leaf extract of *C.sativa* exhibit marked behavioural changes like aggressiveness, erratic movement, jumping, stunned position, rapid operculamovement, vertical position, air gasping and death demonstrated a sensitive indicator of physiological stress in fish. Water quality parameters indicates that *C.sativa* leaf extract significantly affected the water quality. pH value in the T₄ was 5.0 which is lower than the recommended pH value for fresh water fish. (Noga,1996) recommended pH range of 6.5 to 8.5 for fresh water fishes, indicating acidic condition as toxicant strength increases. The acidity of the water probably could be the cause of the decrease in Dissolved Oxygen content of the water and increase in Alkalinity. *C.sativa* is one of the widely used piscicidal plants that is known to contaminate water and also stuns fishes and other aquatic organisms. The acute toxicity of *C.sativa* on fish has been reported by many authors (Onusiriuka and Ufodike, 2002). The LC₅₀ values for *C.sativa* was found to be -44g/l. Fishes exposed to toxicants undergo stress, which is a state of re-established homeostasis, a complex suite of mal adaptive responses (Chrousos, 1998). The 96 hours LC₅₀ had earlier been reported by Oronsaya and Ogbebo (1997) to be 0.4mg/l for copper sulphate. Hence, knowledge of this could help in fish pond and water management.

Conclusion

In conclusion, this work reviewed the effect of *C.sativa* to *C.gariepinus* (that is the toxicity, phytochemical and behavioural effects) therefore the use of *C.sativa* in higher concentrations as seen in treatment 3 and above for fish bait by artisanal fishermen should be prohibited and registration is needed with the National Agency for Food, Drug Administration and Control (NAFDAC) before *C.sativa* can be used for fish catch in Nigeria. Also fish stupefying plants have historically been used by many fish hunters to stun fish. Therefore, use of plant extract for fishing should be prohibited

References

- Adeyemo, O.K. (2008). Histological alterations observed in the gills and ovaries of *Clarias gariepinus* exposed to environmentally relevant lead concentrations. *Journal of Environmental Health*. 70(9):48–51.
- Angugwo J.N. The toxic effects of cymbush pesticides on growth and survival of African catfish *Clarias gariepinus* (Burchell). *Journal of Aquatic Science*. 2002; 17:85-86.
- Ayotunde, E., Ofem, B.O., (2008). Acute and chronic toxicity of pawpaw (*Caricapapaya*) seed powder to adult Nile tilapia (*Oreochromis niloticus* Linna 1757). *African Journal of Biotechnology*. 7 (3): 22675-2274.
- Chrousos, G. P. (1998). Stressors, stress and neuro-endocrine integration of the adaptive response. *Ann.N. Y. Acad. Sci.*, 851: 311-335.
- Egeruoh A.S, Nwanjo S.O, Onyeonuna N.I, Nwaigwe S.C, and Mbagwu C.B. (2019). Comparative Analysis of *Cannabis sativa* and *Nicotiana tobaccum* as Anaesthesia for the Biosafety of *Clarias gariepinus* Fingerlings for Laboratory Purposes.
- Fafioye O.O. (2001). Lethal and sublethal effect of extracts of *Parkia biglobosa* and *Raphiavinifera* on some fresh water fauna. Unpublished Ph.D thesis, University of Ibadan, Nigeria. p.216.
- Fafioye, O.O., Adebisi, A.A., Fagade, S.O., (2004). Toxicity of *Parkia biglobosa* and *Raphiavinifera* extracts on *Clarias gariepinus* juveniles. *African Journal of Biotechnology*. 3 (11): 627-630.
- Finney, D.J. (1971). *Probit analyses*. 3rd Edn., Cambridge University press, Cambridge, UK, pp:76-80.

- Koesoemadinata,S.,(2000).Acute toxicity of the insecticide formulation of endosuphan, chloropyrifos and chlorofluazuron to three freshwater fish species and freshwater giant prawn. *J.Penelitianperlikan indonwsia*, 4:36- 43.
- Louis ,A.H.,L.W. Diana, H.Patricia and R.S.Elizabeth,(1996). *Pesticides and Aquatic animals*: A guide to reducing impacts on aquatic systems, Virginia cooperative extension. Virginia State University,Virginia,pp:24.
- Lloyd R Pollution and fresh water fish. Fishing News Book,USA.1972,364pp.
- Mahmoud UM, Mekkawy IAA, Sayed AH. Ultraviolet radiation-A (366 nm) induced morphological andhistological malformations during embryogenesis of *Clarias s gariepinus* (Burchell, 1822). *Journal of Photochemistry and Photobiology B: Biology*. 2009;95:117–128.
- Nguyen,L.T.H and Janssen,C.R. (2002). Embryo-larval toxicity tes

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Abundance of fishes in Kankia dam, Katsina and their catch-per-unit-efforts***Babatunde Taofik Ademola¹ Kabir Sani², and Babangida Abdulkarim¹**¹Department of Biology, Umaru Musa Ya'radua University, P.M.B. 2218, Katsina State, Nigeria²National Open University of Nigeria, Katsina State

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Abstract

A survey of fish species, their abundance, and catch-per-unit-efforts in capture fisheries of Kankia Dam, Katsina state was carried out between September 2018 and February 2019. Three hundred and fifty five (355) individuals of 12 different species of fishes belonging to eight families were recorded during the study. The dominant family was Mormyridae comprising 31.26% of all the species recorded. In order of dominance, other fish families recorded were Cichlidae, Claridae, and Bagridae constituting 26.48%, 20.85, and 8.73% abundance respectively. The catch-per-unit-effort was found to be highest for Tilapia species, *Oreochromis niloticus* (0.886 kg/net/hr) and *Tilapia zilli* (0.762 kg/net/hr) while *Bagrus bayed* in the was the next high *cpuf* with a value of 0.57 kg/net/hr. The *cpuf* was found not to follow the trends in abundance even though a significantly high correlation (0.61) was found between the two. The gill nets were the major gears being used in the dam fisheries. Consideration for species that are abundant and susceptible to catches is important for conservation and sustainable management.

Keywords: Kankia dam, fish abundance, catch-per-unit-effort.

Introduction

In every society, there is a dominant economic activity engaged by a large population. Fishes are important elements in the economy of many nations as they have been essential components in the diet of many people for a long period (Jennings, *et al.*, 2016). The food of most Nigerians is dominated by cereals, although Nigeria has high aquatic resources which haven't been exploited properly (Watts, 2013). In Kankia Dam, the fishery activity has been of critical importance to the local economy as a vital source of food and income, and the fishing is more in dry seasons due to low water level. Most of the fishermen use monofilament gillnet. In this study, the composition of fish species in Kankia Dam was determined and their catch-per-unit effort. The monitoring of water bodies used directly or indirectly for fisheries for the knowledge of the composition of aquatic resources is important for conservation strategy (Ecoutin *et al.*, 2005). The catch per unit effort (CPUE) from commercial and recreational fisheries has been used for the assessment of fish populations assuming proportionality between CPUE and abundance (Harley *et al.*, 2001). CPUE is also dependent on spatial patterns of fisheries (Grüss *et al.*, 2019). The determination of parameters like abundance, CPUE, and diversity is an important tool for biologists to understand community structure. The changes in species assemblage, abundance, and composition have been considered to be a response to the loss of biodiversity or biotic factors (Schleiger, 2000).

Materials and Methods

The study area was Kankia Dam, in Kankia Local Government Area of Katsina State, Nigeria. The Dam was impounded on river Hudu in 1976 by the Federal Government of Nigeria for irrigation and human domestic activities. It covers an estimated area of 600m². The dam collapsed in 2013 and was rebuilt (Ibrahim, 2013). The maximum surface area normally occurs at the end of the rain season in September. Thereafter, the water recedes so that the minimum level is reached just before the start of rains in June. The fish samples were collected along the length of the Kankia Dam from fishermen's catches. The gill nets of the fishermen have a mesh size of (2.5cm) stretched across the length of the water body. Each net measured about 6m long and 2m. The nets were set in the evening hours at 6 pm and removed in the morning between 6 am. The fish caught were removed, sorted, and counted. The total weight of the fish was taking per species and the catch-per-unit effort (CPUE) was determined using C_i/E_i , where C_i is the catch of i species (kg) and E_i is the net soaking time (12 hours). Morpho-metrical features of the fish specimens were used for fish species identification following the method described by Olaosebikan and Raji (1998). The abundance of each identified species was recorded and expressed in percentage.

Results and Discussion

The fish species composition, percentage abundance, and Catch-per-unit-effort were given in Table 1. 355 individuals of 12 different species of fishes belonging to 8 families were recorded in the Kankia dam gill net fishery during the study. The dominant family was Mormyridae comprising 31.26% of all the species recorded. Next to Mormyridae in order of dominant families were Cichlidae, Claridae, and Bagridae constituting 26.48%, 20.85, and 8.73% of species recorded respectively (Table 1).

This study and other reported findings in Dams around the study area (Bala *et al.*, 2009) showed that mormyrids well abound in Katsina inland waters. This indicated the extent of fish fauna homogeneity in Kastina inland water, even though some have been dammed. Lawson and Olusanya (2010) described that species richness as related to the differences in the species assemblage in a given area as a fundamental unit used to access homogeneity of an environment. *Lates niloticus* was found to be the most abundant species in Ikere River and Ikere dam (Adeosun *et al.*, 2009). Within an ecosystem, the abundance of fish species may also be different by season as Adadu *et al.* (2019) reported that *C. gariepinus* was most abundant in all seasons in River Okpokwu, Benue State in 2015 while, Tilapia was dominant in the subsequent year

Table 1: Fish composition of gill net catches in Kankia dam

Fish families / Species	Total	% Abundance	Catch-per-unit-effort (Kg/net/hour)
Cichlidae			
<i>Oreochromis niloticus</i>	58	16.34	0.886
<i>Tilapia zilli</i>	24	6.76	0.762
<i>Hemichromis Fasciatus</i>	12	3.38	0.219
Centropomidae			
<i>Lates niloticus</i>	4	1.13	0.152
Cyprinidae			
<i>Cyprinus carpio</i>	9	2.54	0.186
Bagridae			
<i>Bagrus bayed</i>	31	8.73	0.570
Mormyridae			
<i>Hyperopsis bebe occidentalis</i>	68	19.15	0.552
<i>Petrocephalus Bane</i>	43	12.11	0.264
Characidae			
<i>Alestes Baremoze</i>	27	7.61	0.223
Claridae			
<i>Clarius anguillaris</i>	58	16.34	0.322
<i>Clarius gariepinus</i>	16	4.51	0.155
Schilbidae			
<i>Schilbe mytus</i>	5	1.41	0.089

Therefore, spatial-temporal and seasonal changes in fish composition and abundance in water bodies are a continuous study, and factors that influence this need to be understood for species conservation. Modifications of large rivers system and blockage of fish movement, alteration of spawning areas, reduction in food sources, are some of the changes in the hydrograph (Pegg *et al.*, 2003) which consequently affect fish ecology. The catch-per-unit-effort was found to be highest for Tilapias with values of 0.886 and 0.762 kg/net/hr for *Oreochromis niloticus* and *Tilapia zilli* respectively. However, the *Bagrus bayed* was the next high CPUE with a value of 0.57. The CPUE does not generally follow the trends in abundance as it takes into consideration the weight of the specimen. Although a significantly high correlation, (0.61) was found between the two. Catch-per-unit-effort is often used to monitor wildlife populations concerning harvesting and time. CPUE showed no relationship with abundance across in most studies (Allen *et al.*, 2020). The diversity indices of fish fauna in the Kankia dam during the study revealed

dominance (D) 0.1269, Shannon wiener (H) 2.213, and Margalef (1.873). The study showed that the Family Cichlidae was the most diverse in terms of the number of species with *O. niloticus* having the highest proportion in Kankia Dam.

References

- Adeosun, F. I. (2009). Annual Pattern on Abundance and Sex Ratio Distribution of Selected Fish Fauna of Ikere Gorge Reservoir, Oyo State, Nigeria. *Borneo Journal of Resource Science and Technology* 9(1): 1-13.
- Adadu, M. O., Garba, A. A., and Mshelia, J. P. (2009). Diversity and abundance of fish species in river Okpokwu, Benue state, Nigeria. *International Journal of Fisheries and Aquatic Studies*. 7(6): 55-60
- Allen, M. L., Roberts, N. M. and Bauder, J. M. (2020) Relationships of catch-per-unit-effort metrics with abundance vary depending on sampling method and population trajectory. *PLoS ONE* 15(5): e0233444.
- Bala, U., Lawal, I., Bolorunduro, P. I., Oniye, S. J., Abdullahi, S. A., Bichi, A. H. (2009). Study of ichthyofauna of daberam reservoir, katsina state. *Bayero Journal of Pure and Applied Sciences*, 2(2): 172 - 174
- Ecoutin, J. M., Richard, E., Simier, M. and Albaret, J. J. (2005). Spatial versus temporal patterns in fish assemblages of a tropical estuarine coastal lake: The Ebrie Lagoon (Ivory Coast). *Estuarine, Coastal and Shelf Science* 64: 623-635.
- Jennings, S., Stentiford, G. D., Leocadio, A. M., Jeffery, K. R., Metcalfe, J. D., Katsiadaki, I. and Verner-Jeffreys, D. W. (2016). Aquatic food security: insights into challenges and solutions from an analysis of interactions between fisheries, aquaculture, food safety, human health, fish and human welfare, economy and environment. *Fish and Fisheries*, 17(4): 893-938.
- Harley, S. J., Myers, R. A. and Dunn, A. (2001). Is catch-per-unit-effort proportional to abundance?. *Canadian Journal of Fisheries and Aquatic Sciences*, 58(9), 1760-1772.
- Lawson, E. O. and Olusanya, O. M. (2010). Fish diversity in three tributaries of River Ore South west, Nigeria. *World Journal of Fish and Marine Sciences*. 2(6): 524-531. ISSN 2078-4589
- Grüss, A., Walter, J. F., Babcock, E. A., Forrestal, F. C., Thorson, J. T., Lauretta, M. V., and Schirripa, M. J. (2019). Evaluation of the impacts of different treatments of spatio-temporal variation in catch-per-unit-effort standardization models. *Fisheries Research*, 213: 75-93.
- Ibrahim, Y. A. (2013). 50 Farms Destroyed in Katsina as Dam Collapses Weekly Trust www.dailytrust.com.ng/weekly/index.php
- Margalef, R. (1968). Perspectives in ecological theory.
- Olaosebikan, B. D. and Raji, A. (1998). Field guide to Nigerian freshwater fishes.
- Pegg, M. A., Pierce, C. L. and Roy, A. (2003). Hydrological alteration along the Missouri River basin: a time series approach. *Aquatic Sciences*, 65(1), 63-72.
- Schleiger, S. (2000). Use of an index of biotic integrity to detect effects of land uses on stream fish communities in west-central Georgia. *Trans. Am. Fish. Soc.*, 129: 1118-1133
- Watts, M. J. (2013). *Silent violence: Food, famine, and peasantry in northern Nigeria* (Vol. 15). University of Georgia Press.

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Distribution and Relative Abundance of Macrobenthic Invertebrates of Elechi Creek, Port Harcourt, Rivers State

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Abstract

The study on distribution and relative abundance of microbenthic invertebrates of Elechi Creek was carried out to assess and measure the health status of the aquatic ecosystem. Elechi Creek is one of the aquatic ecosystems of interest that have received array of industrial and domestic wastes. It is therefore important to routinely monitor the status of the creek to avoid deterioration of this aquatic ecosystem. Five sampling points were selected and sampled for 6 months. Samples were collected, labelled appropriately, preserved and taken to laboratory for analysis. The microbenthic invertebrates were identified with appropriate keys. Statistical analysis was done using statistical package for social sciences (SPSS) version 19. The results showed that there were seventeen taxa group in terms of distribution and a total of 446 individuals in the family of Sesamidae recorded (3) species, Ocypodidae (1), Nereididae(2) and Tellinidae (2) respectively. The relative abundance revealed that Polychaeta had the highest abundance of (77.4%), Bivalvia (6.05%) crustacean 9.91%) and Gastropoda (7.17%), while Pisces had the least (0.22%). The relatively high abundance of Polychaeta in the study area was an indication of high level of pollution in the aquatic environment or water body.

Keywords: Macrobenthic invertebrates, Elechi Creek, Aquatic Environment , Pollution

Introduction

Macrobenthic invertebrates are mainly bottom dwelling organisms measuring over 1mm in size and usually, can be retained in sieves of about 0.6mm aperture (Iyagbaye *et al.*, 2017). These organisms are often used to assess sediment quality in both fresh and marine aquatic ecosystem, since their abundance and distribution depict the changing environmental condition. While their presence or absence serves as indicator of both periodic and persistent anthropogenic influences on the aquatic ecosystem (Amar *et al.*, 2015). Over two decades, the study of macrobenthic invertebrates have received attention in biomonitoring and measurement of ecological health status of most aquatic ecosystem (Bassey *et al.*, 2020).

Elechi creek is one water body of great interest due to array of anthropogenic activities prominent within the area, resulting in discharge of industrial effluents, household waste and other anthropogenic waste capable of deteriorating the water quality. This creek provides the inhabitants of the area with seafood, water for domestic use, irrigation and cooling agent for multinational companies along the creek (Otene and Ukwue, 2018). The usability of water sourced from this creek is dependent on the water quality which is a pre-requisite in determining the health of any society (Okey-Wokeh *et al.*, 2021). Unfortunately, there has dearth of information on distribution and relative abundance of macrobenthic invertebrates of Elechi Creek, which would have served as indicator to ascertain the status of the water body.

Materials and Methods

Description of the Study Area

Elechi creek is one popular water route in Port Harcourt. It is located behind the Rivers State University, Port Harcourt and it lies within 6°44'N longitude and latitude 4°38' and 5°5'E in the eastern part of the Niger delta as shown in figure 1. Elechi creek is a brackish water system influenced by tidal fluxes. It has mangroves vegetation. This water system is of great importance due to the increasing level of fishing, waste disposal, transportation and sand mining activities.

Sample collection

The sampling of macrobenthic invertebrates was done for the period of 6 months (September, 2018 to February, 2019). Sediments were collected from five different locations of the creek on monthly basis to cover up dry and wet seasons respectively. The sample collection was done by the use of Ekman grab of 225m which was sent down into the bottom sediment using the messenger to close and grab some quantity of sediment made of 5 haul. The grab was then removed under suction pressure. Composite samples was composed from each station and put into labelled transparent container for subsequent determination of the sediment particle sizes.

The remaining benthic samples were washed through a sieve of 1mm x 1mm mesh size to collect the benthos. The washed sediment with macrobenthic were poured into a wide mouth labelled plastic container and preserved with 10% formalin solution to which Rose Bengal (dye) had been added. The preserved samples were later taken to the laboratory for analysis. The preserved animals were later identified to their lowest taxonomic group under light and stereo dissecting microscope and counted. The identification was carried out using keys by Days (1967) and Pennak (1978). The monthly percentage occurrence and relative numerical abundance of macrobenthic were estimated. Samples were carried out using ANOVA at probability (0.05) using SPSS version 19 to compare the relative abundance and diversity of macrobenthic invertebrates

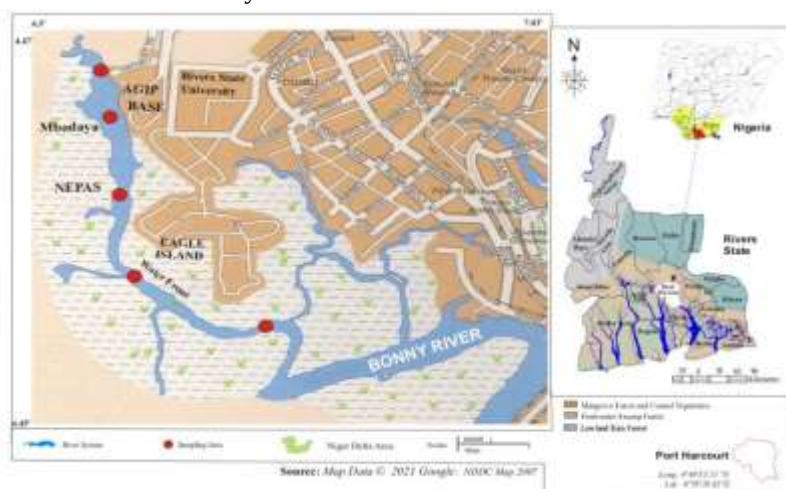


Figure 1: A Map of the Study Area Showing Sampling Stations

Results and Discussion

The result in table 1 showed the overall macrobenthic invertebrate composition, distribution, abundance and frequency of occurrence in the study area. Table 1 revealed that seventeen (17) taxa 446 individual were recorded. The breakdown showed that family of *Sesarmidae* has 3 species, *Ocypodidae* has 1, *Potamididae* has 1, *Neritidae* has 1, *Portunidae* has 1, *Cyprinodontidae* has 1, *Palaemoidae* has 1, *Gammaridae* has 1, *Alpheidae* has 1, *Solecurtidae* has 1, *Capitallidae* has 1, *Nereidida* has 2, *Tellinidae* has 2 species. The relative abundance trend of macrobenthic invertebrate in Elechi Creek showed that *Polychaeta* had the highest, constituting 77.4%, the others were *Bivalvia* 6.05%, *crustacean* 9.19%, *gastopoda* 7.17% and the least was *Pisces* 0.22% (Table 2).

Macrobenthic invertebrates obtained from Elechi Creek, had seventeen taxa constituting species belonging to twelve families, six classes and four phyla, which is in variance with the work of Hart (1994) that reported forty-three species from mangrove swamp of Port Harcourt. This finding is similar to that of Ansa (2005) who reported twenty-eight families, six classes and five phyla in Andoni flats. This result could be attributed to the variable substrate composition such as mud, debris, silt and aquatic macrophytes that provided different microhabitats for macrobenthic invertebrate (Iyagbaye et al., 2017).

It was observed that polychaeta were more dominant with six families, followed by crustacean with two families. This is in accord with the report of Zabbey (2002) in Woji Creek the upper reaches of Bonny River, but in contrast with Hart and Zabbey (2005). The dominance of polychaeta in the study area could be attributed to their high level of pollution tolerance. Table 3 shows the distribution of macrobenthic invertebrates across stations. The most dominant

species is *Capitellacapitata* with 50.50% abundance while the least dominant species across the stations is *Xiphophorusmaculatus* which amount to 0.00% in station 3 and 0.33% in station 4 and 5.

The abundance of *Capitellacapitata* in the water body is based on the fact that they are more tolerant to pollutions than any other species in the ecosystem, hence, they are pollution indicators in the water body. The variations in taxa and number of individuals between stations were not significantly different ($P > 0.05$).

Tables1: Check list of macrobenthic invertebrate in Elechi Creek, Port Harcourt

Family	Species
Sesarmidae	<i>Sesarmaangolensis</i> <i>Armaseselegans</i> <i>Perisesarmahuzardi</i>
Ocypodidae	<i>Ucatangeri</i>
Potamididae	<i>Tympanotonosfuscatus</i>
Neritidae	<i>Neritina oweniana</i>
Portunidae	<i>Callinectespallidus</i>
Poeciliidae	<i>Xiphophorusmaculatus</i>
Palaemonidae	<i>Macrobrachiumvollenhoveni</i>
Gammaridae	<i>Gammarusroeseli</i>
Alpheidae	<i>Alpheus bellulus</i>
Solecurtidae	<i>Tagelusadansonii</i>
Capitellidae	<i>Capitellacapitata</i>
Nereididae	<i>Neanthesfucata</i> <i>Nereisdiversicolor</i>
Tellinidae	<i>Tellinanympalis</i> <i>Tellinafabula</i>

Table2: Relative abundance of each class of individual benthic organism

CLASS	Total No of individuals	Mean total No of individuals	% abundance
Polycheta	345	172.5	77.4
Bivalvia	27	13.5	6.05
Crustacea	41	20.5	9.19
Gastropoda	32	16	7.17
Pisces	1	0.5	0.22
TOTAL	446	223	100.00

Table 3: Distribution of macrobenthic Invertebrates across stations

	STATION 1	STATION 2	STATION 3	STATION 4	STATION 5	SIG
<i>Nereisdiversicolor</i>	36.67 ± 6.41 ^b	27.67 ± 4.52 ^b	36.67 ± 5.82 ^b	22.00 ± 3.73 ^b	7.17 ± 1.40 ^a	0.001
<i>Neanthesfucata</i>	42.67 ± 13.60 ^a	22.67 ± 8.01 ^a	18.67 ± 8.88 ^a	17.50 ± 8.94 ^a	21.50 ± 13.79 ^a	0.485
<i>Carpitellacapitata</i>	50.50 ± 13.72 ^a	48.50 ± 9.69 ^a	58.33 ± 13.31 ^a	50.00 ± 9.36 ^a	75.00 ± 9.15 ^a	0.443
<i>Tellinanympalis</i>	10.17 ± 2.89 ^{a,b}	18.33 ± 4.01 ^b	6.17 ± 2.14 ^{a,b}	3.50 ± 2.13 ^a	11.17 ± 6.45 ^{a,b}	0.107
<i>Tellinafabula</i>	2.00 ± 0.68 ^{a,b,c}	3.67 ± 1.33 ^{b,c}	1.33 ± 0.49 ^{a,b}	0.50 ± 0.22 ^a	4.50 ± 0.96 ^c	0.013
<i>Tagelusadansonii</i>	5.83 ± 2.95 ^{a,b}	4.00 ± 2.08 ^{a,b}	1.33 ± 0.93 ^a	7.17 ± 3.46 ^{a,b}	14.33 ± 5.77 ^b	0.124
<i>Alpheus bellulus</i>	0.17 ± 0.17 ^a	0.17 ± 0.17 ^a	0.00 ± 0.00 ^a	1.17 ± 0.40 ^b	0.17 ± 0.17 ^a	0.007
<i>Gammarusroeseli</i>	0.17 ± 0.17 ^a	1.00 ± 0.68 ^a	1.67 ± 1.17 ^a	0.33 ± 0.21 ^a	0.00 ± 0.00 ^a	0.317
<i>Macrobranchiumvollenhoveni</i>	0.0 ± 0.00 ^a	0.00 ± 0.00 ^a	3.67 ± 0.80 ^b	1.16 ± 0.6 ^a	0.00 ± 0.00 ^a	0.000
<i>Sesarmaangolensis</i>	0.33 ± 0.21 ^a	7.33 ± 1.89 ^b	0.33 ± 0.21 ^a	0.00 ± 0.00 ^a	0.33 ± 0.21 ^a	0.000
<i>Armaseselegans</i>	0.33 ± 0.21 ^a	0.17 ± 0.17 ^a	1.00 ± 1.00 ^{a,b}	4.17 ± 1.24 ^c	3.00 ± 1.06 ^{b,c}	0.010
<i>Perisesarmahuzardi</i>	1.17 ± 0.54 ^b	1.00 ± 0.26 ^{a,b}	0.17 ± 0.17 ^{a,b}	0.00 ± 0.00 ^a	0.83 ± 0.40 ^{a,b}	0.099
<i>Ucatangeri</i>	0.83 ± 0.54 ^a	1.83 ± 0.65 ^{a,b}	0.60 ± 0.40 ^a	1.00 ± 0.00 ^a	3.17 ± 0.65 ^b	0.012
<i>Tympanatonosfuscatus</i>	0.67 ± 0.49 ^a	6.67 ± 1.78 ^c	3.17 ± 0.70 ^{a,b}	5.67 ± 1.02 ^{b,c}	3.17 ± 0.31 ^{a,b}	0.003
<i>Neritina oweniana</i>	0.83 ± 0.54 ^a	0.67 ± 0.33 ^a	0.33 ± 0.33 ^a	0.00 ± 0.00 ^a	0.17 ± 0.17 ^a	0.380
<i>Callinectespallidus</i>	0.33 ± 0.33 ^a	0.00 ± 0.00 ^a	0.83 ± 0.31 ^{a,b}	1.33 ± 0.49 ^b	0.00 ± 0.00 ^a	0.017
<i>Xiphophorusmaculatus</i>	0.17 ± 0.17 ^a	0.17 ± 0.17 ^a	0.00 ± 0.00 ^a	0.33 ± 0.21 ^a	0.33 ± 0.33 ^a	0.764

Conclusion and Recommendations

The overall results of distribution and abundance of macrobenthic invertebrates across the stations in Elechi Creek showed that Polychaete were abundant because of pollution tolerance nature of these organisms. This is a clear indication that Elechi Creek was seriously polluted water quality and macrobenthos. Routine monitoring and assessment of the water quality should be done to forestall further pollution which directly or indirectly might pose serious health risk to men. It is therefore recommended that further studies should be directed to find out the roles of these identified polychaets on biodegradation of pollution and the physiological impact of wastes in Elechi Creek, Port Harcourt, Rivers State.

References

- Amar, M. Dattesh, V. D., Subhash, S., Venkat, K. & Arga, C.A (2015). Distribution and Abundance of benthic Microorganisms in and around Visakhapatnam Harbour on the east coast of India. *Journal of the Marine Biological Association of the UK*, 95(2), 215-231
- Ansa, E.J. (2005). Studies of the benthic macrofauna of the Andoni flats in the Niger Delta River, Niger Delta, Nigeria. *Journal of Fisheries International*, 4(1), 13-18.
- Bassey, B.O., Nosazeogie, E.O., Izge, M.A., Bello, B.O., Abiodun, O. (2020). Diversity of microbenthic invertebrates in relation to some selected water quality parameters in Lagos Lagoon, Nigeria. *Journal of Scientific and Technical Research*, 30(1), 22993-23002.

- Days, J.A. (1967). A monograph on the Polychaeta of Southern Africa Part I Errantia. British Museum of Natural History, London. Pp: 458.
- Hart, A.I. & Zabbey, N. (2005). Physico-chemistry and benthic fauna of Woji Creek in the Lower Niger Delta, Nigeria. *Environment and Ecology*, 23(2), 361-368.
- Hart, A.I. (1994). The ecology of the communities of benthic macro fauna in the mangrove swamp of Port Harcourt area of the Niger Delta. PhD. Thesis, University of Port Harcourt, Rivers State, 262.
- Iyagbaye, L.A., Iyagbaye, R.O. & Omoigberale (2017). Assessment of Benthic macro-invertebrates of freshwaters ecosystem: A case study of Ovia River (Iguoriakhi), Edo State, Nigeria. *European Scientific Journal*, 3(26), 405-422.
- Okey-Wokeh, C.G., Obunwo, C.C. & Wokeh, O.K. (2021). Evaluation of water quality index using physicochemical characteristics of Ogbor River in Aba, Abia State, Nigeria. *Journal of Applied Science and Environmental Management*, 25(1), 47-51.
- Otene, B.B. & Ukwe, I.O. (2018). Evaluation of heavy metal accumulation in water and sediment from Elechi Creek, Port Harcourt, Nigeria. *International Journal of Geography and Environmental management*, 4(1), 1-9.
- Pennak, R. (1978). Fresh-water invertebrates of the United States.
- Zabbey, N. (2002). An ecological survey of benthic macroinvertebrates of Woji Creek, off the Bonny River System Rivers State. M.Sc. Thesis, University of Port Harcourt, pp: 102.

9

Morphological features and molecular identification of African Sickfish, *Drepane africana* (Osório, 1892) off the Niger Delta coast, Nigeria

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Abstract

African sicklefish, *Drepane africana* is the only member of the family Drepaneidae found and reported in Nigerian waters. Despite its prominence in catches there is a dearth of detailed published information on morphological features and molecular identification of the species off the Niger Delta coast. This study was carried out to investigate morphological, morphometric (truss and conventional) and meristic characters, as well as DNA sequence. Samples of *D. africana* (n=2,143) were collected between April, 2013 and September, 2015 from seven sampling stations off the Niger Delta coast, Nigeria. The morphometrics (conventional and truss) and meristic characters of the fish were studied. DNA sequencing of the samples were also carried out. Data were analyzed using descriptive statistics and Principal Component Analysis (PCA). There were no variation in the numbers of all the meristics characters counted except in the number of pelvic fin spine, anal fin spine and atlas. The mean of total length, body depth and pectoral fin were 26.6±5.5, 15.1±1.8 and 11.7±1.0 cm respectively. The first four principal components (PCs) of the truss measurement accounted for 93% of the variation in the population, PCA revealed that the observed differences mainly were from the posterior and dorsal part of the fish. The range of 98-100% definitive identity matches of the species with GenBank records shows that all the sequenced samples have been correctly identified as *Drepane africana*.

Keywords: *Drepane africana*, Morphometrics, Meristics characters, DNA sequencing, Niger Delta.

Introduction

Drepane africana is one of the three species of *Drepane*, the only genus of the family Drepaneidae reported worldwide. *Drepane* is colourful and good as marine aquarium fish because of its beautiful and vibrant colour patterns and, which make it among the targeted genera marine aquarium and recreational fish in Australia (Robert *et al.*, 1993) and India (Mandal *et al.*, 2012). The other two *Drepane* species are *D. punctata* and *D. longimana*.

Drepane africana is the only member of the family found and reported off Nigerian coast (Schneider, 1990). It is found and reported in lagoons and estuarine habitats (Oluwajoba *et al.*, 2017). Members of the Family Ehippidae (also known as spade fish) are similar to the *D. africana*. It is vital to study the taxonomy of *D. africana* in order to provide definite proprietary identification of the species by the use of DNA sequence as complementary to the morphology, meristic characters and morphometric measurements. The objectives of the study is to describe the morphological features and molecular identification of *Drepane africana* using morphological, morphometric (truss and conventional) and meristic character as well as DNA sequence.

Materials and Methods

The fish samples were collected monthly from April 2013 – September, 2015 off Akwa Ibom and River States at Niger Delta, Nigeria. 16 meristic features were counted and 18 selected conventional morphometric characters were measured using measuring board and electronic vernier caliper (Mitutoyo digital Caliper) to the nearest millimeter for each 2,143 specimens examined. Truss network illustrated by Strauss and Bookstein (1982), Bookstein *et al.* (1985) and Bookstein (2018) for fish sample morphometrics was applied to construct a network of measurements for 140 specimens (i.e. 20 fish samples from each sampling station randomly selected) were used for this study. Muscle tissue (500 g) was cut out from caudal fin of 16 *D. africana* samples. The generated 16 samples 16S rRNA sequences were re-affirmed in GenBank based on maximum BLAST scores with matching sequences between 87% - 92% coverage and 98% - 100% identity. The data based were accessed for species identification between January and April, 2016. All the sequences were placed in GenBank. Data were analysed using descriptive statistics, regression analysis and Principal Component Analysis (PCA) at $\alpha_{0.05}$.

Result

The colour of *D. africana* is silvery with eight vertical broad dark grey stripes on the upper parts of the body which are more pronounced on juvenile. The ctenoid scales were finely serrated and extended even to the dorsal as well as anal fins. The eyes are big. Dorsal fin spines of *D. africana* were unsegmented and unbranched while the soft rays were segmented and branched. The pectoral fins were elongated and extended, nearly the whole body length reaching the caudal region. Anal fin has spines and the caudal fin was not attached to dorsal and anal fin. The meristic counts for *D. africana* are shown in Table 1. Dorsal fin spines of *D. africana* ranged from VIII and IX (8.02 ± 0.4). The dorsal fin spine of VIII (80%) and IX (20%) had 1st dorsal fin spine which were usually very small not easily detectable in adult but visible in juveniles. Dorsal fin rays ranged from 20 and 21 (20.70 ± 0.7) while pelvic and anal fin spines recorded were I and III respectively. The atlas of the species recorded was two and vertebra ranged from 22 and 23 (22.4 ± 0.2). There were variation in the number of all the meristics characters except in the number of pelvic fin spine, anal fin spine and atlas. Table 2 shows the morphometric features of *D. africana* off Niger Delta coast, Nigeria. The size of *D. africana* encountered ranged from 10.2-39.4 cm (24.6 ± 5.5) total length, 7.8-33.2 cm (19.1 ± 8.8) standard length and 17.9-1,350 g (381 ± 302.5) of body weight. The body depth of *D. africana* off Niger Delta coast, Nigeria encountered ranged 6.2-19.0 cm (15.1 ± 1.8), pectoral fin length ranged 5.5-20.0 cm (11.7 ± 1.6) and the snout length ranged 0.5-2.9 cm (2.2 ± 0.5).

Table 1: Meristic characters of *Drepane africana* off Niger Delta coast, Nigeria

S/N	Character	Range	Mean $\pm$ Standard deviation
1	Dorsal fin spine	VIII -IX	8.02 ± 0.4
2	Dorsal fin ray	20-21	20.70 ± 0.7
3	Pectoral fin ray	13-16	15 ± 0.6
4	Pelvic spine	I	1
5	Pelvic ray	4-7	6.2 ± 1.2
6	Anal fin spine	III	3
7	Anal fin ray	17-18	17.1 ± 0.3
8	Scale on lateral line	42-51	46 ± 3.1
9	Scale above lateral line	10-18	12.6 ± 4.3
10	Scale below lateral line	21-30	26 ± 2.5
11	Branchiostegal rays	6-10	7 ± 0.8
12	Gill rakers (Upper limb)	6-9	6.4 ± 0.2
13	Gill rakers (Lower limb)	11-14	12.2 ± 0.4
14	Atlas	2	2
15	Vertebra	22-23	22.4 ± 0.2
16	Caudal fin ray	19- 23	20.2 ± 0.6

Table 2: Morphometric characters of *Drepane africana* off Niger Delta coast, Nigeria

S/N	Morphometric measurements	Range	Mean $\pm$ Standard deviation
1	Body weight (g)	17.9-1,350	381 ± 302.5
2	Total length (cm)	10.2-39.4	24.6 ± 5.5
3	Standard length (cm)	7.8-33.2	19.1 ± 8.8
4	Head length (cm)	2.3-12.2	7.8 ± 1.9
5	Head depth (cm)	3.5-16.4	12.1 ± 4.3
6	Pre-orbital length (cm)	0.7-3.9	2.0 ± 1.2
7	Post-orbital length (cm)	0.9-5.0	3.4 ± 1.7
8	Eye diameter (cm)	0.9-3.2	2.5 ± 0.6
9	Body depth (cm)	6.2-19.0	15.1 ± 1.8
10	Snout length (cm)	0.5-2.9	2.2 ± 0.5
11	Caudal peduncle length (cm)	0.3-3.0	2.0 ± 0.3
12	Caudal peduncle depth (cm)	1.0-4.1	3.2 ± 0.6

13	Pre-dorsal length (cm)	4.4-17.9	12.0±4.6
14	Distance from nostril to snout (cm)	0.7-3.6	3.1±0.9
15	Distance between the two eyes (cm)	0.8-4.8	3.5±0.8
16	Mouth width (cm)	1.5-4.0	2.8±0.6
17	Distance from eye to snout (cm)	0.7-4.4	3.0±0.9
18	Pectoral fin length (cm)	5.5-20.0	11.7±1.6

The first four Principal Component (PCs) accounted for approximately 93% of the variation (PC 1 = 66.97%, PC 2 = 13.3%, PC 3 = 8.28% and PC 4 = 4.67%). There was very little difference in the percentage of variance of PC 2, PC 3 and PC 4, with low scores occurring. Negative and positive loading of morphometric measurements with different magnitudes in all the PCs signifying that the size effect on the morphometric measurements had been totally removed before analysis. The first PC which accounted for 66.97% of the total variability had largest contributions from mainly the caudal peduncle depth (0.9773), the caudal peduncle length (0.9697) and dorsal fin length (both the spine and ray) (0.7252 and 0.6425). Principal Component 2 which accounted for 13.3% of the variability had high contributions from the body depth (0.6624) and the distance between neurocranium and dorsal fin (0.8695). Principal Component 3 accounted for 8.28% of the variability with high contributions from body depth (0.7522) and dorsal part of the head (0.5589). Principal Component 4 which accounted for 4.67% of the variation, had high contribution only from the distance between the beginning of pelvic fin and the beginning of anal fin (0.6829) which is abdominal part of *D. africana*. The 16 samples successfully extracted were amplified and sequenced. The 16 specimens sequenced successfully generated products containing DNA.

The average number of the mitochondrial 16S rRNA gene sequenced is 598±3.41 nucleotide base pairs per sample (all >590 bp) and the sequence analyses showed average of nucleotide frequencies as A=20.3%, T=29.4%, G=29.5% and C=20.8%. There was high sequence similarity scores (98-100%) to sequences from the same species in the Gen Bank. All sequences were deposited in GenBank.

Discussion

The morphological features such as number of stripes (8) on the body and mouth type reported in this study are similar to those observed by Schneider (1990) and Carpenter and De Angelis (2016) for *Drepane africana* generally in Eastern Central Atlantic Ocean. The beautiful silvery colour and the eight vertical striped at the upper part of the species which are more pronounced in juveniles revealed that the species may also be considered as an ornamental species, especially at juveniles. In the present study, there were variations in the number of most of the characters counted except the pelvic fin spine, anal fin spine and atlas that were uniform in all the samples observed during the study. These three meristic characters could be used to ascertain the identification of *D. africana*. Reed *et al.* (1967) and Hold and Reed (1972) found that fin rays of same species do not differ much

The head length was almost one third of standard length of the fish. The eye size was large about 40 percent of head depth. The gill arch contains 6 to 9 rakers on upper limb and 11 to 14 on lower limb. Spines were present on the gill of the juveniles. Ahmed (2017) reported 6 to 8 rakers on upper limb and 10 to 12 on lower limb for *Drepane longimana*. The tropical species had a slightly higher variation in gill raker numbers between the species (Moodie, 2004). The number of gill rakers is proportional to the inter-raker spacing difference (Amundsen *et al.*, 2004). The morphology of gill rakers may be influenced by physiological factors such as water temperature and salinity (Loy *et al.*, 1999).

Ahmed (2017) also reported 8, 3, 1 and 19 – 22 for dorsal fin spine, anal fin spine, pelvic fin spine and dorsal fin ray respectively for *Drepane longimana*, while the dorsal fin spine, anal fin spine, pelvic fin spine and dorsal fin ray recorded for *Drepane africana* during the study are 8-9, 3, 1 and 20–21 respectively. Meristic features such as number of gill rakers, dorsal fin spine and dorsal fin ray can be used to differentiate between the *Drepane africana* and any other member of the genus. This present study revealed that analyses of meristic characters of *D. africana* can only be used to differentiate the species from other species but not to differentiate within the population or with the same species from another location. Historically, morphometric research was used to classify organisms and consider species diversity (Dean *et al.*, 2004). Special morphometric character of African sicklefish is its long pectoral fin, which extend almost to the caudal fin of the fish. The morphometric measurements from the PCs analysis showed both positive and negative but with separate magnitudes signifying that effect of the size on the morphometric measurements taken had been totally eliminated before analysis (Wessels *et al.*, 2010).

The PCA showed that morphometric differentiation of the species was high in the dorsal and posterior regions of the fish population of *D. africana* caught off the Niger Delta coast. The present results demonstrated significant differences in morphometric traits among the populations of *D. africana*. This morphometric differentiation, however, was not supported by meristic traits. Such differences between the populations maybe related to different habitat characteristics, such as temperature, turbidity, food availability, water depth and flow. For example, head length was correlated with small prey size (Gatz, 1979). Kessler *et al.* (1995) considered that a benthophagous species had differences in habitat at high flow that corresponded to differences in morphology, with the species having robust bodies and large pectoral fins, which allowed them to withstand currents on smoother substrata. Consequently the present analysis suggests high morphological differentiation among *D. africana* populations. The detected differentiation may be related to differential environmental conditions such as temperature, turbidity, food availability, and water depth.

Kumari *et al.* (2020) opined that both morphometric and meristic variations exist between stocks and population. The morphometric and meristic traits of the species indicate the trait should be used as complementary not alternative, to the same ambiguity. There is also possibility of variability among these traits in different habitat and prey predatory relationship. The 16S rRNA markers used in this study were useful for the identification of *D. africana*. Identification success rates of 98-100% in all of the 16 different sequencing indicate that the 16S rRNA fragment is effective for identifying fish. The range of 98-100% definitive identity matches of the species with GenBank recorded revealed that all the sequenced samples have been correctly identified as *D. africana* (Landi, *et al.*, 2014).

Conclusion

The morphometric differentiation in the dorsal part and posterior regions implies that these are the targeted areas for changes in external taxonomic feature of the species which are useful to identify morphometric changes in the species as a whole. Identification of fishes based on morphological characteristics could also be complemented with molecular characterization.

References

- Ahmed, M. S., Obaida, A., Ahmed, S. and Latifa, G. A. 2017. New record of Concertina fish, *Drepane longimana* (Perciformes: Drepaneidae) from the St. Martin's Island, Bangladesh. *International Journal of Fisheries and Aquatic Studies* 5.6: 164-165
- Amundsen, P. A., Born, T. and Vaga, G. H. 2004. Gill raker morphology and feeding ecology of two sympatric morphs of European white fish (*Coregonus lavaretus*). *Annales Zoologici Fennici* 41: 291-300.
- Bookstein, F. L., 2018. *A course in Morphometrics for Biologists; Geometry and Statistics for Studies of Organismal form*. Cambridge: Cambridge University Press. 556pp
- Bookstein, F. L., Chernoff, B. C., Elder, R. L., Humphries, J. M., Smith, G. R. and Strauss, R. E. 1985. Morphometrics in Evolutionary Biology. *Academy of Natural Sciences of Philadelphia Special Publication* 15: 277pp.
- Cakmak, E. and Alp, A. 2010. Morphological differences among the Mesopotamian spiny eel, *Mastacembelus mastacembelus* populations. *Turkish Journal of Fisheries and Aquatic Science* 10: 87-92.
- Carpenter, K. E., and De Angelis, N., (eds.) 2016. *The living marine resources of the Eastern Central Atlantic. Volume 4: Bony fishes Part 2 (Perciformes to Tetradontiformes) and Sea turtles*. FAO Species Identification Guide for Fishery Purposes, Rome, FAO. Pp. 2343–3124.
- Dean C. A., Rholf F. J. and Dennis E. S. 2004 Geometric morphometrics: Ten Years of progress following the revolution. *Italian Journal of Zoology* 71: 5-16.
- Gatz, A. J. 1979. Ecological morphology of freshwater stream fishes. *Tulane Studies in Zoology and Botany* 21: 91–124.
- Hold, M. and Reed, W. 1972. *West African fresh water fish*. West African nature handbooks, Longmans, 67pp.
- Kessler, R. K., Casper, A. F. and Weddle, G. K. 1995: Temporal variation in microhabitat use and spatial relations in the benthic fish community of a stream. *American Midland Naturalist* 134: 361–70.
- Kumari, S., Jaiswar, A. K., Jahageerdar, S., Chakraborty, S. K., Kumar, T. 2020. Morphometric and meristic variation of congeneric sciaenid fishes *Otolithes cuvieri* (Trewavas, 1974) and *Otolithes ruber* (Schneider, 1801) from Maharashtra, West coast of India *Indian Journal of Geo Marine Sciences* 49. 01: 80-86
- Landi, M., Dimech, M., Arculeo, M., Biondo, G., Martins, R., Carneiro, M., Carvalho, G. R., Brutto, S. L. and Costa, F. O. 2014. DNA Barcoding for Species Assignment: The Case of Mediterranean Marine Fishes. *PLoS ONE* 9.9: 1 - 9

- Loy, A., Corti, M. and Cataudella, S. 1999. Variation in gillraker number during growth of the sea bass, *Dicentrarchus labrax* (Perciformes: Moronidae), reared at different salinities. *Environmental Biology of Fish* 55: 391–398.
- Mandal, B., Arunava, M., Subrata, S. and Samir, B. 2012. Study on the Ornamental Fin Fish of Indian Sundarbans with Special Reference to Few Floral Sources for Carotenoid Pigmentation. *World Journal of Fish and Marine Sciences* 4.6: 566-576.
- Moodie, G. E. 2004. Gill raker variation and the feeding niche of some temperate and tropical freshwater fishes. *Environmental Biology of Fish*.13.1: 71-76.
- Oluwajoba, E. O., Fakayode, O. S., Oluboba, T. F., Williams, A. B., Ukaonu, S. U. and Fola-Matthews, O. O. 2017. Seasonal variation in species abundance, diversity and composition of fish fauna in Lagos Lagoon, Nigeria. *Nigeria Journal of Fisheries* 14: 1281-1288.
- Reed, W., Burchard, J., Hopson, A. J., Jenness, J. and Yaro, I. 1967. *Fish and Fisheries of Northern Nigeria*. Ministry of Agriculture, Northern Nigeria. 226pp
- Strauss, R. E. and Bookstein, F. L. 1982. The truss: Body form reconstruction in morphometrics. *Systematic Zoology* 31: 113–135.
- Wessels, G., Moloney, C. L. and van der Lingen, C. D. 2010. The effects of freezing on the morphometrics of sardine *Sardinops sagax* (Jenyns, 1842). *Fisheries Research* 106: 528-534.

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Acute Toxicity of a Corrosion Inhibitor Chemical on Nile Tilapia (*Oreochromis niloticus*)

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Abstract

Corrosion of metals is a menace that makes the use of corrosion inhibition chemicals inevitable to avoid gross economic losses especially in oil and gas industry where facilities are installed in aquatic environment. These chemicals can constitute major ecological problems to living organisms. This study aimed to determine the acute toxic effect of a corrosion inhibition chemical on *Oreochromis niloticus* (Nile Tilapia) a relatively toxicant sensitive fresh water fish species. After the Range Findings (Exploratory Tests) was carried out to determine the upper and lower limits of test concentrations in 48hrs, the Definitive Test ensued with a total of 10 animals being exposed to 5 different concentrations (75, 125, 185, 235 and 300mg/l) of the test chemical alongside the control experiment in triplicates. Physico-chemical parameters measured were within desirable ranges through the test period ($p > 0.05$). Mortality was noted to rise (0 to 9.67) with a corresponding decrease in lethal concentration (LC_{50}) values as the test chemical concentration and time increases. The 96-h LC_{50} was 173.497mg/l, this according to Joint Group of Expert on the Scientific Aspect of Marine Environmental Protection (GESAMP), indicates relatively low toxicity of the corrosion inhibitor to *Oreochromis niloticus*. Nevertheless, environmental friendly protocols should be followed in the application of these chemicals in the aquatic environment.

Key word: Acute toxicity, Corrosion Inhibitor, *Oreochromis niloticus*

Introduction

The corrosion of metals is a worldwide problem which challenges metallurgical, chemical, construction and oil industries. The presence of many corrosive substances in crude oil and installation of facilities in aquatic environment, the corrosion problems experienced in oil and gas industries, has always been of great significance, with consequences related result to those of natural disaster (Tamalmani and Husin, 2020). Corrosion in aquatic environment usually results from chemical and biological activities that take place in operational environments, while the former which has to do with reactions of electrolytes in the water with structural metals of the facility is usually referred to as Electrochemical corrosion, the later termed Biocorrosion involves biological activities especially those of microorganisms and other fouling species (Oyewo, 1989; Turkiewicz *et al.*, 2013; Brzeszcz and Turkiewics, 2015).

However, continuous exposure of the pipeline surfaces to impurities and sources of corrosion such as sulfur and chromate is totally unavoidable. Operators in petroleum oil and gas industry find the use of corrosion inhibitors inevitable. Brzeszcz and Turkiewics (2015), categorized corrosion inhibitors into different chemical groups such as amines, imidazoline and heterocyclic groups, their application in oil industry generally involves the use of hydrophobic corrosion inhibitors. The use of corrosion inhibitors for controlling corrosion, if not applied in an environment friendly manner could constitute a major source of ecological problems especially in operational water bodies. This often arises as a result of toxic effects (acute and chronic) on vast range of indigenous living resources in the environment. Other potential hazards that could be associated with corrosion inhibitor include their persistence in environment, ability for bio-accumulation and thereafter may lead to bio-magnification and mammalian toxicity. Therefore, effective and efficient control measure for corrosion requires application of corrosion inhibitors that combat both electro-chemical corrosion and bio-corrosion (Tamalmani and Husin, 2020).

Acute toxicity evaluation is a common bio-monitoring practice to assess environmental friendliness and compatibility of potential toxicants in environment. It's usually used to determine the concentration of the chemical that will exert acute (deadly) effect on the test organism within a short period (usually 96 hour). Fish such as (tilapia species) and shrimps (such as *machrobrachium* and *Paleamonetes* spp.) are common candidates for acute toxicity test especially due to their relative sensitivity to toxicants, numerical abundance in the environment and their socio-economic values (Benli and Zikin, 2010). The acute toxicity of some toxicants on freshwater species of tilapia, *Oreochromis niloticus* (Nile Tilapia) has been earlier evaluated (Chindahet *al.*, 2004; Karasuet *al.*, 2009 and

Vroumsiaet *al.*, 2014). In order to determine the potential effect of corrosion inhibitor chemical on this highly valued fresh water living resource, the present study hence aimed to evaluate the acute toxicity effect of a Corrosion inhibitor chemical on the post-fries of *Oreochromis niloticus*.

Materials and Methods

Test chemical and Animals

The corrosion inhibitor chemical was received from Department of Petroleum Resources (DPR), Victoria Island Lagos, while the *Oreochromis niloticus* (Nile Tilapia) was sourced from Fish Hatchery of Aquaculture Department of NIOMR where the fish was bred. The post-fries of *O. niloticus* were ten days old on collection from the hatchery; 17 days old at commencement of Toxicity Test. Body weight of the fish ranged from 0.05g to 0.12g with a mean value of $0.09\text{g} \pm 0.017$. Total length ranged from 1.2cm to 1.8cm with a mean value of $1.55\text{cm} \pm 0.153$. The fish were moved to the Toxicity Test Lab in a 56cm x 41cm x 35cm plastic container at a density of 50 fish per liter. In the Toxicity Lab, the fish were transferred to similar size acclimatization glass tanks at same density.

Acclimatization: During acclimatization, the fish were fed with 0.3mm diameter formulated starter feed for Tilapia (with 30% crude protein) at 7% of total body weight per day. Feeding was stopped two days to commencement of the test. By changing water every other day, desirable physico-chemical parameters were maintained as follows: Dissolved oxygen: 6 – 8mg/l; pH: 7 – 8; Conductivity: 35.50µsm/cm; Temperature: 23 – 27°C; Photoperiod: About 12 hours. No mortality was recorded during acclimatization period.

Range Findings (Exploratory Tests)

The exploratory test was carried out by exposing ten test organisms to various concentrations of the chemicals ranging from 75 to 100,000mg/l. The least concentration that produced 100% mortality and the highest concentration with almost zero mortality was noted and subsequently used for the definitive test.

Definitive Tests

The Static non-renewal toxicity test method was used. Based on the observations during exploratory tests, a total of ten test animals were exposed to five different concentrations of 75, 125, 185, 235 and 300mg/l of Corrosion Inhibitor chemical. The triplicate test was carried out in a 2-liter solution of each concentration in a glass Aquarium Tank (28cm X 13cm X 15cm), with the Control experiment which had the animals exposed to only the habitat water. Test tanks were assessed every 24 hours for mortality, dead animals were removed and percentage mortality records were taken. Manifestation of death of the animal was taken as cessation of body movement and failure to respond to prodding.

Physico-chemical Parameters During the toxicity testing experiment, the dissolved Oxygen, water temperature, pH, Salinity TDS and Conductivity were monitored using DO meter (LaMotte: DO 6 Plus), pH meter (HANNA: pH-009 111 ATC); Refractometer; TDS meter (LaMotte TDS 6 Plus) respectively.

Data Analysis

Acute toxicity dose data (Mortality data) were analyzed using a computer-based Probit Analysis tool pack (Finney, 1971). This was used to determine 96-hour LC_{50} (concentration that is likely to result in 50% mortality) of the Corrosion Inhibitor chemical against *O. niloticus*.

Results

Exploratory Test of the toxic effect of Corrosion Inhibitor Chemical on *O. niloticus*

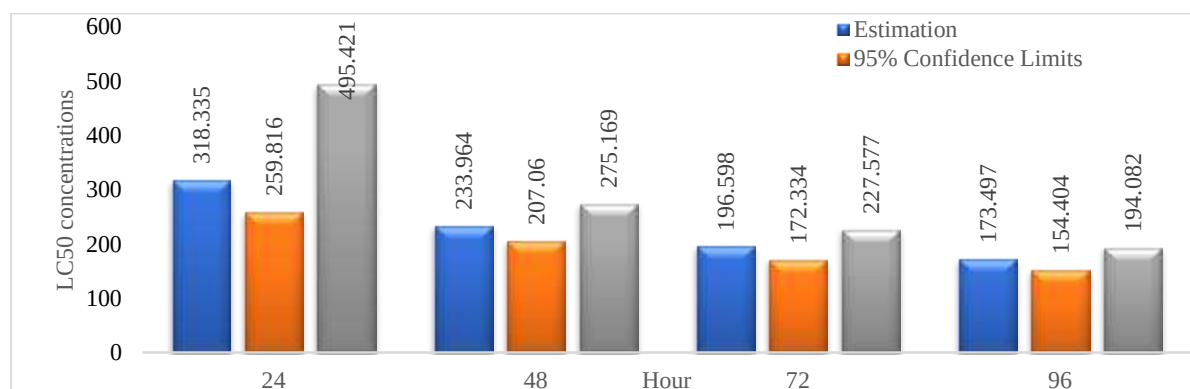
During the exploratory test, 300mg/l was the least concentration that produced 100% mortality while the highest concentration with almost zero mortality was 75mg/l. Therefore, concentrations which ranged from 75 to 300mg/l (75, 125, 185, 235 and 300mg/l) were used for definitive test of Corrosion Inhibitor chemical against *O. niloticus*.

Definitive test of the toxic effect of Corrosion Inhibitor Chemical on *O. niloticus*

There was no mortality observed in the triplicate control experiment, however, a rise in mortality was noted with increase in the concentration of the Corrosion inhibitor chemical and time as depicted in Table 1. The corresponding acute toxic effect of the chemical on the fish expressed as the LC_{50} also gradually increase from 318.34 mg/l to 233.96mg/l between 24 and 48h, 196.60mg/l at 72h with the final 96Hour LC_{50} of 173.497mg/l with 95% Confidence Limits of 154.404 to 194.082mg/l, (Figure 1).

Table 1 Mean $\pm$ SD values of Mortality during Corrosion Inhibitor chemical Assay on *O. niloticus*

CONCENTRATION (mg/l)	NUMBER OF EXPOSED ORGANISMS	24HR	48HR	72HR	96HR
0 (Control)	10	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00
75	10	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.67 $\pm$ 0.58	0.67 $\pm$ 0.58
125	10	1.33 $\pm$ 0.58	1.67 $\pm$ 0.58	2.00 $\pm$ 0.00	2.00 $\pm$ 0.00
185	10	2.33 $\pm$ 0.58	3.00 $\pm$ 0.00	4.33 $\pm$ 0.58	5.33 $\pm$ 0.58
235	10	3.00 $\pm$ 0.00	4.33 $\pm$ 1.15	5.67 $\pm$ 0.58	6.67 $\pm$ 1.15
300	10	4.67 $\pm$ 1.53	7.33 $\pm$ 0.58	8.33 $\pm$ 0.58	9.67 $\pm$ 0.58

Fig 1.0: LC₅₀ Values of Corrosion Inhibitor Chemical on *O. niloticus***Physico-chemical Parameter during the definitive test**

The mean value of the various physico-chemical parameters monitored are shown in Table 2. All the parameters were within acceptable limits (pH: 6.70-7.67; Temperature: 26.23-28.85°C and Dissolved Oxygen: 4.96-7.20 mg/L)

Table 2. The Mean $\pm$ SD of Physico-chemical Parameters during Corrosion Inhibitor chemical Assay on *O. niloticus*

CONCENTRATION (mg/L)	24hrs				96hrs			
	pH	Temp (°C)	TDS (mg/L)	DO (mg/L)	pH	Temp (°C)	TDS (mg/L)	DO (mg/L)
0	7.52 $\pm$ 0.02	27.20 $\pm$ 0.06	620.00 $\pm$ 0.24	7.20 $\pm$ 0.02	7.50 $\pm$ 0.12	27.40 $\pm$ 0.02	634.00 $\pm$ 0.24	6.40 $\pm$ 0.02
75	7.67 $\pm$ 0.21	28.85 $\pm$ 0.05	715.33 $\pm$ 0.58	5.84 $\pm$ 0.05	7.27 $\pm$ 0.21	28.15 $\pm$ 0.05	738.33 $\pm$ 0.58	5.14 $\pm$ 0.05
125	7.53 $\pm$ 0.21	28.53 $\pm$ 0.46	741.00 $\pm$ 985	5.72 $\pm$ 0.09	7.13 $\pm$ 0.21	27.83 $\pm$ 0.46	764.00 $\pm$ 9.85	5.02 $\pm$ 0.09
185	7.37 $\pm$ 0.31	26.93 $\pm$ 0.12	770.33 $\pm$ 9.07	5.66 $\pm$ 0.04	6.97 $\pm$ 0.31	26.23 $\pm$ 0.12	793.33 $\pm$ 9.07	4.96 $\pm$ 0.04
235	7.10 $\pm$ 0.10	27.80 $\pm$ 0.95	746.00 $\pm$ 1.00	6.06 $\pm$ 0.27	6.70 $\pm$ 0.10	27.10 $\pm$ 0.95	769.00 $\pm$ 1.00	5.36 $\pm$ 0.27
300	7.60 $\pm$ 0.10	27.03 $\pm$ 0.21	791.33 $\pm$ 6.43	6.22 $\pm$ 0.06	7.20 $\pm$ 0.10	26.33 $\pm$ 0.21	814.33 $\pm$ 6.43	5.52 $\pm$ 0.06

Discussion

The desirable levels of most of the physico-chemical parameters that were measured throughout exposure periods show that the water used for dilutions and test media was of good quality. This also indicates that the toxic components of the chemicals (Corrosion Inhibitor) only exerted their lethal effects on test animals but with insignificant impact on physico-chemical parameters. Consequently, the very high survival levels (> 90%) recorded in controls after 96 hours of exposure indicate that the mortalities recorded during the tests were as a result of acute toxicity of the Corrosion inhibitor chemical on the fishes. Corrosion always results from chemical activities and biological processes especially those of micro-organisms and other fouling organisms (Turkiewicz *et al.*, 2013; Brzezcz and Turkiewicz, 2015). Thus, active ingredients of corrosion inhibitor will include biocidal components which could have exerted the toxic effects on the test species. The lethal effect of biocides on fish and other aquatic organisms usually results from disruption of transmission of nerve impulses (Vroumsiaet *et al.*, 2014) and severe damage to vital body organs such as liver, gills and hematological parameters (Friday *et al.*, 1996; Chindah *et al.*, 2001 and 2004).

The decreasing trends recorded in LC₅₀ values of the chemical from 24 hour to 96 hour on *O. niloticus* indicate that the lethal effect on the fish increased with time during the test period. Similar increase in toxicity level with time was reported for Chlorpyrifos, an organophosphate pesticide on *T. guineensis* as reported by Chindah *et al.* (2001). Based on classification of Joint Group of Expert on the Scientific Aspect of Marine Environmental Protection (GESAMP 2002), the 96hours LC₅₀ values of 173.497mg/L placed this corrosion inhibitor chemical in Numerical Rating for Aquatic Toxicity Category '1' for *Oreochromis niloticus*. This is an indication of relatively low toxicity of the corrosion inhibitor chemical to this fish species. Moreover, it is important to note that findings from laboratory toxicity test only serve as fair indicators of lethal capacity of the toxicants on test organisms. The results could however not be extrapolated for exact toxicity situations in the wild due to complexity of nature (Oyewo and Don-Pedro, 2006). There are several environmental factors which can reduce either toxicity level or potency of a toxicant in natural water body. Perhaps, there is possibility that large and expanse water body with physical processes such as current would possess buffering capacity to often bring down concentrations of toxicants below acute toxic levels.

Conclusion and Recommendations

The results of this study suggest that the corrosion inhibitor chemical studied has low acute toxic effect on freshwater species of Tilapia, *Oreochromis niloticus*. Although the chemical exert a low toxicity level, the application of it in an environment friendly manner is highly recommended.

References

- Brzezcz J and Turkiewicz A (2015). Corrosion Inhibitors- Application in Oil and Gas Industry. *InstytutNaftyiGazuNAFTA-GAZ*. ROK LXXI Nr 2: 67-75.
- Chindah A. C, Sikoki F. D, and Vicent-Akpu I. (2001). The effects of organochlorine pesticides on acommon wetland fish, *Tilapia guineensis* *Journal of Agriculture, Environment and Biotechnology* 1 (2): 71- 82
- Chindah A. C, Sikoki F. D and Vicent-Akpu I. (2004). Toxicity of an organophosphate pesticide (Chlorpyrifos) on a common Niger Delta wetland fish, *Tilapiaguineensis* (Blecker1862). *Journal of Applied Sciences and Environmental Management*. 8 (2): 11-17.
- Friday S. L M, Andrw D. M, Hart A. D. M and Langton S. D. (1996). Effects of exposure to an organophosphate pesticide on the behavior and use of cover by captive Starlings. *Environmental Toxicology and Chemistry*. 15 (9): 1590-1696.
- Garcia-Santos S., Fontainhas-Fernandez A. and Wilson J. M. (2006). Cadmium Tolerance in the Nile Tilapia, *Oreochromis niloticus* following acute exposure. *Environmental Toxicology* 21 (1): 33-46
- GESAMP (2014, 2nd Ed.). Revised GESAMP Hazard Evaluation Procedure for Chemical Substances Carried by Ships (IMO/FAO/UNESCO-IOC/WMO/IAEA/UN/UNEP/UNIDO/UNDP) Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection, Rep. Stud. GESAMP No. 64, 126pp.
- KarasuBenli, A.,Selvi, M.,Sarıkaya, R.,Erkoç, F. and Koçak, O. (2010). Acute Toxicity of Deltamethrin on Nile Tilapia (*Oreochromisniloticus* L.1758) Larvae and Fry. *Gazi University Journal of Science*, 22 (1), 1-4
- KausalyaTamalmani and HazlinaHusin (2020). Review on Corrosion Inhibitors for Oil and Gas Corrosion Issues. *Journal of Applied. Science*. (10) 3389.
- Otitolaju A. A, Don-Pedro K. N, and Oyewo E. O. 2007. Assessment of potential ecologicaldisruption based on heavy metal toxicity, accumulation and distribution in media of theLagos Lagoon. *African Journal of Ecology*.45:454-463.

- Oyewo E. O. (1989). Organotin Compounds, Fouling and the Marine Environment. *Ocean & Shoreline Management* 12: 285-294.
- Oyewo E. O. and Don-Pedro K. N. (2003). Toxicity ranking of four heavy metals of industrial source to six resident animals of a tropical estuarine lagoon. *Environmental Toxicology and Chemistry* 83 (1-4): 87-97
- Oyewo E. O. and Don-Pedro K. N. (2006). Acute toxicity and induced weight changes in laboratory tests with Mn and Cu against *Tilapia guineensis* (Dumeril) and *Tympanotonus fuscatus* (Linne). *Journal of Environmental Biology* 27 (2): 327-334
- Turkiewicz A., Brzezcz J. and Kapusta P. (2013). The Application of Biocides in the Oil and Gas Industry. *Instytut Nafty i Gazu NAFTA-GAZ. ROK LXIX*: 103-111.
- Vroumsia T., Djaouda M. and Cesaire F. (2014). Acute toxicity of Moncalm 400SI (monocrotophos) and Profenalm 720 ec (profenofos) on *Oreochromis niloticus*. *Journal of Applied Biosciences* 78:6763-6770
- Yildrin M. Z., Benil A., Selvi M., Ozkal A., Erkoc F. and Kocak O. (2006). Acute toxicity, Behavioral changes and Histopathological effects of Deltamethrin on tissues of Nile Tilapia, *Oreochromis niloticus* fingerlings. *Environmental Toxicology* 21 (6): 614-620.

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Bioaccumulation of Chromium in *Clupea harengus* from Nigerian waters Sold in Anyigba Main Market, Kogi State, Nigeria

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Abstract

Metals are quite significant to us since they play an important role in biological system but its accumulation above a threshold might be deleterious to human health. The study was designed to assess the chromium concentration of *Clupea harengus* purchased from Anyigba main market. Thirty (30) fish samples of *Clupea harengus* were collected from three different fish stands and their wet body weight measured and afterwards dissected to separate the body parts into head, tail, flesh, and bone tissue. Inductively coupled plasma was used to analyze the chromium concentration of each part. The mean chromium concentrations in the head, flesh, bone and tail tissues were 0.45mg/kg, 0.25mg/kg, 0.11mg/kg, and 0.05mg/kg respectively showing that all body parts of the fish samples had chromium concentration higher than WHO permissible limit (0.1mg/kg) except the tail. Consumption of *Clupea harengus* should be regulated by relevant agencies to reduce the effect of chromium concentrations among the populace.

Keywords: Heavy metals, *Clupea harengus*, Aquatic pollution

Introduction

Pollution has become a major issue around the world in recent times and aquatic ecosystem in particular is prone to heavy metal contaminants as a result of urbanization and rapid industrialization. Controlling the influx of these contaminants has been a major problem to the environmentalists and consequently leading to serious pollution of the water bodies across the globe (Bakshi and Panigrahi, 2018).

Unlike organic pollutants, heavy metals are high-density non-biodegradable metallic elements with long-lasting toxic effects (Ukohaet *al.*, 2014; Sthanadaret *al.*, 2015), which upon accumulation in the aquatic environment are transferred to the aquatic biota through different pathways (Khalifaet *al.*, 2010). Heavy metals have the ability to alter species diversity within an ecosystem (Türkmenet *al.*, 2009). The presence of toxic heavy metals in fish can invalidate their beneficial effects for human consumption. Several unfavorable effects of heavy metals to human health have been known for long time. These include serious threats like renal failure, liver damage, cardiovascular diseases, and even death (Al-Busaidiet *al.*, 2011).

Fish are often at the top of aquatic food chain and when pollutants build up in the food chain, fish are widely used to evaluate the health of aquatic ecosystems. (Mansour & Sidky, 2002; Farkaset *al.*, 2002). Thus, many local and international monitoring programs have been established in order to assess the quality of fish for human consumption and to monitor the health of the aquatic ecosystem (Mechet *al.*, 2010). The concern about the high levels of trace metals in foods has prompted several statutory bodies such as the World Health Organization to establish maximum allowable concentrations for some of the metals in food (Oluyemi and Olabanji, 2011). Thus the World Health Organization (WHO) as well as the Food and Agriculture Organization (FAO) of the United Nations state that monitoring eight elements in fish Hg, Cd, Pb, As, Cu, Zn, Fe, Sn is obligatory while the monitoring of others though not obligatory may be useful (Staniskieneet *al.*, 2006).

The effect of heavy metal on human and the entire environment has made it imperative to study and identify the main source of contamination in order to enable us take proactive measures in eradicating or bringing it to a minimum bearable limit. *Clupea harengus* is a common species of fish sold and consumed in virtually all parts of the globe. Nevertheless, the bioaccumulation of heavy metals and particularly chromium in *Clupea harengus* has not received great deal of attention compared to other heavy metals and fish species consumed by humans. Hence, this study seeks to bridge the gap in knowledge of the bioaccumulation of chromium in tissues of frozen *Clupea harengus* from Nigerian waters sold in Anyigba main market, Kogi State, Nigeria.

Materials and Methods

Study Area

This study was carried out in Anyigba, a town in Dekina Local Government Area of Kogi State with an estimated population of 189,976 individuals is located between latitudes 7°15'N-7°29'N and longitudes 7°11'E-7°32'E, with an average altitude of 385 meters above sea level and total land mass area of 420Sq.km (Ifatimehin, 2012). Anyigba Main Market is located on latitude 7°30'14"N-7°30'21"N and longitudes 7°10'27'E-7°11'30"E (GPRS). According to Ifatimehin and Ufuah (2016), the land use and economy of the area is predominantly agrarian in the first instance but fast changing because of the transformation instigated in the economic landscape by the presence of the State University. Anyigba is known for its commercial activities as it is located strategically in the eastern part of the State making it accessible to other local governments for trading in varieties of goods.

Sample Collection and Pre-Treatment

Thirty (30) samples of frozen fish (*Clupeaharengus*) were purchased randomly from fish vendors in Anyigba Main Market, Kogi State, Nigeria and were transported to the laboratory for pre-treatment and subsequent analysis. Identification of fish to species level was done by a specialist in the Fisheries and Aquaculture unit of the department of Animal and Environmental Biology, Kogi State University Anyigba.

Distilled water was used to rinse the body surfaces of the purchased fish samples to remove any mechanical additives and afterwards allowed to defrost at room temperature. Using stainless steel dissecting kits, each fish was dissected and different body parts including the head, tail, flesh, and bone tissue were used in the digestion procedure.

Sample Digestion

The wet method of digestion, with a little modification, was used to carry out the sample digestion as described by Lawal-Are *et al.* (2018). Using Tissue Balance PCE-LSZ 200C, 10 g of each fish body part (wet body weight) from the fish sample was weighed and put into a 100ml beaker. For wet digestion, 10 ml of freshly prepared solution comprising 1:1 v/v hydrogen peroxide/nitric acid was added, and the beaker was covered with a watch glass and set aside for 1 hour for the initial reaction. The beaker was then placed on a hotplate for about 2 hours and allowed to boil at a temperature of 160 °C until it became crystal-clear, curtailing its volume at 2–2.5 ml. The digested sample was then passed through a Millipore membrane filter (0.45 µm, type HV) and diluted up to 25 ml with distilled water. This filtrate of each fish sample was then analyzed for chromium (Cr), using inductively coupled plasma (PerkinElmer, model: Optima 7000 DV ICP-OES) with detection limits of 1.40, 0.07, and 0.25 µg/L (ppb).

Statistical Analysis

The results obtained were subjected to simple descriptive statistics to determine the mean and standard deviation. Statistical Analysis System (SAS) version 9.0 portable was used.

Results

The result of bioaccumulation of Chromium concentrations in tissues (head, flesh, bone, tail) of *Clupeaharengus* ranges from 0.04 to 0.48, and the maximum concentration limit (0.1mg/kg) for chromium (MCL) for the various batches in this present study is as represented in table 1. In batch 1, the concentration of chromium in various tissues were 0.42 mg/kg, 0.23 mg/kg, 0.11 mg/kg, and 0.04 mg/kg for head, flesh, bone, and tail respectively, showing a high level of chromium concentration (0.42 mg/kg) in the head and lowest (0.04 mg/kg) in the tail of the fishes (figure 1). Similarly, the tissue of the fish head in batch 2 shows the highest (0.48 mg/kg) concentration of chromium, while the tail tissue also showed the lowest concentration of chromium. Furthermore, high chromium concentration (0.44 mg/kg) was also observed in the head tissue of the fishes in batch 3, and the lowest concentration (0.05 mg/kg) was seen in the tail. However, the head of fishes in batch 2 shows the highest (0.48 mg/kg), while the head of fishes in batch 1 shows the lowest (0.42 mg/kg) concentration of chromium, the flesh of fishes had the highest (0.27 mg/kg) and lowest (0.23 mg/kg) concentration of chromium. The highest concentration of chromium in the bone was seen in batch 2 and the lowest concentration was seen in batch 3, the tail of fishes shows highest concentration of chromium in batches 2 and 3 (0.05 mg/kg) and the lowest concentration in batch 1 (0.04 mg/kg) when compared across batches.

The concentration of chromium in the head of fishes in all batches (1, 2, and 3) ranges from 0.42 mg/kg to 0.48 mg/kg, which is very high when compared to the WHO permissible limit at 0.1 for chromium. However, concentration of chromium in the flesh of fishes in all batches has a range of 0.23 mg/kg to 0.27 mg/kg, which is

higher than the WHO permissible limit (0.1 mg/kg) for chromium. Also, the concentration of chromium in the bone of fishes in all batches ranges from 0.1 mg/kg to 0.12 mg/kg, which is slightly higher than the WHO permissible limit (0.1 mg/kg) for chromium. Nevertheless, the concentration of chromium in tail of fishes across all batches shows a range of 0.04 mg/kg to 0.05 mg/kg; this is low when compared to the WHO permissible limit (0.1 mg/kg) for chromium (Table 1).

Table 1: Mean Chromium concentration in different body parts of *Clupeaharengus*

Fish parts	body	Chromium Concentration (mg/Kg)				WHO Maximum Concentration Limit
		Batch 1	Batch 2	Batch 3	Mean	
Flesh		0.23±0.05	0.24±0.57	0.27±0.03	0.25±0.02	0.05-0.15
Bone		0.11±0.03	0.12±0.02	0.1±0.01	0.11±0.02	0.05-0.15
Head		0.42±0.10	0.48±0.07	0.44±0.06	0.45±0.11	0.05-0.15
Tail		0.04±0.02	0.05±0.01	0.05±0.02	0.05±0.03	0.05-0.15

Discussion

This study assessed the concentration of chromium in tissues of *Clupea harengus*. The result showed that the concentration of chromium in the sample fish is high when compared to the WHO permissible limit (WHO, 2017). The head of *Clupea harengus* fish accumulates more chromium than other parts and followed by the flesh but both exceeded the WHO recommended limit. Whereas the bone of *Clupeaharengus* fish accumulates a slightly higher concentration of chromium than the WHO permissible limit, while the tail of fish which was hardly consumed by many individuals shows minimal concentration of chromium which was lower than the WHO permissible limit.

The result from this study is in accordance with the work of Ukachukwu (2012) who found the concentration of chromium high in the head, skin, and muscle at 6.24±0.77 mg/kg, 5.45±0.58 mg/kg, and 4.88±0.62 mg/kg respectively, and also agrees with the result of Sahar *et al.*, (2014) who found the concentration of chromium in the body of fish at 0.6±0.34 mg/kg. This result is also in agreement with a study of Aslam and Muhammad (2017), stating that Chromium concentration has been found to be highest in head, flesh, and gill of fish. Farkaset *et al.*, (2002) also reported the high concentration of chromium in the body parts of fish, with fish head having the highest concentration.

However, the result of the present study contrasts the result of other researchers across the country which shows that the body of fish had a lower concentration compared to other parts of the body. (Akintujoye *et al.*, 2013, Lawal-Are *et al.*, 2018). This may be attributed to differences in fish species, their physiology and other environmental factors. The high chromium concentration in the head region of the fish studied in this present study could be as a result of the presence of gills at the head region which is noted as a pathway of metal ion exchange from water as well as large surface area that increases the rate of diffusion of metals (Qadir and Malik, 2011). This suggests the fact that the metal accumulation is a function of the concentration of the water in which they are harvested from. This agrees with the findings of Moore and Ramamorthy (Moore and Ramamorthy, 1989).

Conclusion

The concentration of chromium in tissues of *Clupeaharengus* species sold in Anyigba Multipurpose Market Kogi State in this study shows the mean chromium concentration to be higher than WHO permissible limit for chromium. It therefore requires adequate caution in the consumption rate by the populace as increasing accumulation of chromium in the body tissue can lead to increased mortality and incidence of some cancers including lung, larynx, bladder, kidney, testicular, bone, and thyroid cancer in humans.

References

- Akintujoye, J.A., Anumudu, C.I., and Awobode, H.O. (2013). Assessment of Heavy Metal Residue in Water, Fish Tissues, and Human Blood from Ubeji, Warri, Delta State, Nigeria. *Journal of Applied Science and Environmental Management*, 17(2): 291-297.
- Al-Busaidi, M., Yesudhasan, P., and Al-Mughairi, S. (2011). "Toxic metals in commercial marine fish in Oman with reference to national and international standards," *Chemosphere*, 85(1): 67-73.
- Aslam S. and Muhammad A.Y. (2017). Chromium toxicity in fish: A review article. *Journal of Entomology and Zoology Studies*. 5(3): 1483-1488.

- Bakshi A, and Panigrahi A K. (2018). A comprehensive review on chromium induced alterations in fresh water fishes. *Toxicology reports*. 5. 440-447.
- Farkas, A., Salanki, J. and Specziar, A. (2002). Relation between growth and the heavy metal concentration in organs of bream, *Abramis brama* L. populating Lake Balaton. *Archives of Environmental Contamination and Toxicology*, 43: 236-243.
- Ifatimehin O.O., Adeyemi J.O., and Ajayi M.E. (2012). An Analysis of the Environmental Correlates of Malaria Risk in Kabba Town, Nigeria. *Journal of Geography, Environment and Planning*. 8 (1): 54–59.
- Ifatimehin O.O, and Ufuah M.E. (2016). The Effect of a Spatial Structure on Rural Economy: A Case of Kogi State University on Anyigba and its Environ. *Confluence Journal of Environmental Studies*. 1 (2): 61–70.
- Khalifa K.M., Hamil A.M., Al-Houni A.Q.A., and Ackacha M.A. (2010). Determination of heavy metals in fish species of the Mediterranean Sea (Libyan coastline) using atomic absorption spectrometry. *International Journal of Pharmaceutical Technology Research* 2: 1350–1354.
- Lawal-Are, A.O., Adekugbe, A.L. and Odusoga, A.W. (2018). Assessment of heavy metal content in imported and local fish and crustacean species obtained within Lagos metropolis. *Animal Research International*. 15 (2): 3034 – 3040.
- Mansour S.A. and Sidky, M.M. (2002). Heavy metals contaminating water and fish from Fayoum Governorate, Egypt. *Food Chemistry*. 78: 15-22.
- Moore J.W. and Ramamorthy, Heavy metals in natural applied monitoring and impact assessment, Springer-Verlag, New York, NY, USA, 1989.
- Oluyemi, E.A. and Olabanji, I.O. (2011). Heavy metals determination in some species of frozen fish sold at ile-ife main market, South West Nigeria. *Ife Journal of Science*. 13 (2): 355-362.
- Qadir A. and Malik R.N., “Heavy Metals in Eight Edible Fish Species from Two Polluted Tributaries (Aik and Palkhu) of the River Chenab, Pakistan,” *Biological Trace Element Research*, vol. 143, no. 3, pp. 1524–1540, 2011.
- Sahar, M., Alireza, P., and Reza, A. (2014). Analysis and Determination of Trace Metals in Tissues of Fish in Hara Reserve, Iran. *Journal of Toxicology*. p 6.
- Staniskiene, B.; Matusevicius, P.; Budreckiene, R. and Skibniewska, K.A. (2006). Distribution of heavy metals in tissues of freshwater fish in Lithuania. *Polish Journal of Environmental Studies*, 15: 585-591.
- Sthanadar I.A., Sthanadar A.A., Begum B., Nair M.J., Ahmad I., Muhammad A., Zahid M., and Ullah S. (2015). Aquatic pollution assessment using skin tissues of mulley (*Wallago attu*, Bloch & Schneider, 1801) as a bio-indicator in Kalpani river at District Mardan, Khyber Pakhtunkhwa. *Journal of Biodiversity and Environmental Sciences* 6: 57–66.
- Türkmen M., Türkmen A., Tepe Y., Töre Y., and Ateş A. (2009). Determination of metals in fish species from Aegean and Mediterranean Seas. *Food Chemistry* 113: 233–237.
- Ukachukwu, L.K. (2012). Heavy Metal Concentrations in Water, *Clarias gariepinus* and *Tilapia guineensis* from Agodi Lake in Ibadan. Department of Environmental Health Sciences, Faculty of Public Health of Medicine University of Ibadan, Nigeria.
- Ukoha P.O., Ekere N.R., Udeogu U.V., Agbazue V.E. (2014). Potential health risk assessment of heavy metals [Cd, Cu and Fe] concentrations in some imported frozen fish species consumed in Nigeria. *International journal of Chemical Sciences*. 12: 366–374.
- World Health Organisation (2017) Recommendation WHO; Geneva: (Guidelines for Drinking Water Quality). 1: 130.

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Organ differences in heavy metal levels and antioxidant enzymeresponses in *Chrysichthys nigrodigitatus* from Lagos Lagoon

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Abstract

This study evaluated the heavy metal levels in muscle and liver tissues of a commercial fish *Chrysichthys nigrodigitatus* inhabiting Lagos Lagoon, Nigeria. Biomarkers of oxidative stress were determined in the muscle and liver of fish across three sampling stations. There was significant ($p < 0.05$) increase in the concentrations of heavy metal in the liver tissue as compared to the muscle. There was increase antioxidant defense enzymes activities in the liver as compared to the muscle. These results show that Lagos Lagoon is polluted and high metal concentrations in fish may lead to oxidative stress and unsafe for humans as diet.

Keywords: Heavy metals, *Chrysichthys nigrodigitatus*, oxidative stress, Lagos Lagoon

Introduction

Pollution of aquatic habitats with a wide range of contaminants has been a matter of great concern over the last few decades (Okay *et al.*, 2016; Arojoye *et al.*, 2018; Ajani, 2020). Human activities such as domestic and industrial activities along the aquatic environments have extensively contaminated the waterways with heavy metals. The contamination of these metals may have adverse effect on the ecological balance of the recipient habitats and diversity of resident biota (Farombi, *et al.*, 2007; Ajani, 2020). Among the resident biota, fishes are among the aquatic organisms that cannot escape from the adverse effects of these pollutants. Fish are usually used as bioindicators to evaluate the health of aquatic ecosystems (Eroglu *et al.*, 2015). The high levels of metals in tissues, result in the formation of reactive oxygen species (ROS), which are consequences of oxidative stress. The body develop mechanisms to counter the effect of these oxidants by inducing antioxidant defense systems (Eroglu *et al.*, 2015; Abdel-Gawad *et al.*, 2016; Ajani, 2020). These enzymes include superoxide dismutase (SOD), catalase (CAT), and the glutathione triad: reduced glutathione (GSH), glutathione-S-transferase (GST) and glutathione peroxidase (GPx). They all have specific functions in detoxifying the ROS species generated by aquatic pollutants (Farombi *et al.*, 2007; Ajani, 2020). This study evaluated the heavy metal load of muscle and liver tissues of *C. nigrodigitatus* and determine the link between heavy metal levels and biochemical response from each tissue.

Materials and Methods

One hundred and ninety-two *C. nigrodigitatus* fish samples (Apapa $n=61$, Makoko $n=83$ and Ibeshe $n=48$) with average weight of 180g were caught from three sampling stations (Fig 1). Fish was dissected and one gram of muscle and liver was removed. The tissues were placed in a Teflon beaker and digested in an acid solution (HNO_3) in preparation for heavy metal analysis (Kenstar closed vessel microwave digestion) using the microwave digestion procedure (Segbeloyin *et al.*, 2010). The specimens were digested with 5 milliliters of HNO_3 (65%) and filtered with the Whatman Filter Paper no 41 into a 25 milliliters volumetric flask and made up to mark with distilled water (FAO/SIDA, 1983). All digested specimens were analysed in triplicates for the following metals: lead, cadmium and chromium were analysed in muscle and liver by atomic absorption spectrometry using atomic absorption spectrophotometer (Perkin-Elmer AA 700). The equipment was graded with standard solutions formulated from economically available chemicals purchased from Merck KGaA, Germany (Kingston and Jassie, 1988). The antioxidant defense enzyme analysis involves the removal of muscle and liver tissue from fish and washed in ice-cold 0.65% sodium chloride before storage. 0.5 gram of tissue was homogenized with five milliliters of 0.4M phosphate buffer using Teflon homogenizer. The tissue homogenates were centrifuged at 3000rpm at 15mins. The resulting supernatant was used for further biochemical analysis (Magwere *et al.*, 1997). Superoxide Dismutase (SOD) activity evaluated using procedures from Magwere *et al.*, (1997). Catalase (CAT) activity followed procedures from Sinha (1972). Malondialdehyde (MDA) constitute part of the final output of lipid peroxidation. MDA levels was analysed according to Buege and Aust (1978) methods. The total protein estimation was measured with Bicinchoninic Acid (BCA) procedure (Smith *et al.*, 1985). All values for the results are

expressed as mean±standard error. Unpaired student t-test was used to determine significant differences ($p<0.05$) in heavy metal concentrations and antioxidant activities in muscle and liver using Origin 8. All values were considered statistically significant at $P<0.05$.



Figure 1: Map of Lagos Lagoon showing sampling stations

Results

Heavy metals such as lead (Pb), cadmium (Cd) and chromium and antioxidant defense enzymes such as superoxide dismutase (SOD), catalase (CAT) and malondialdehyde levels were analyzed in muscle and liver of fish collected from three sampling stations (Apapa, Makoko and Ibeshe) from Lagos Lagoon. The concentration of Pb in fish muscle was 1.57 ± 0.67 , 1.77 ± 0.58 and 0.17 ± 0.08 , Cd was 0.22 ± 0.51 , 0.61 ± 0.26 , 0.43 ± 0.22 , Cr was 0.97 ± 0.55 , 0.95 ± 0.25 , 2.38 ± 1.20 $\mu\text{g/g.dw}$ in Apapa, Makoko and Ibeshe respectively. The results indicate that lead and chromium levels were relatively higher than other metal in the tissues (Table 1). The liver accumulates relatively higher amounts of heavy metals. The concentration of Pb in fish liver was 2.14 ± 0.99 , 2.08 ± 0.96 and 1.19 ± 0.90 , Cd was 1.51 ± 0.30 , 1.22 ± 0.27 , 0.49 ± 0.32 , Cr was 2.03 ± 0.19 , 1.72 ± 0.35 , 3.67 ± 1.03 $\mu\text{g/g.dw}$ in Apapa, Makoko and Ibeshe respectively (Table 1).

The activities of antioxidant defense enzymes were analysed in fish muscle SOD was 85.46 ± 9.75 , 132.37 ± 6.75 , 110.78 ± 7.16 (U/mg protein), CAT 2.28 ± 0.33 , 4.32 ± 2.52 , 3.36 ± 1.56 (U/mg protein) and MDA 61.39 ± 14.5 , 46.65 ± 10.98 , 29.15 ± 4.41 ($\mu\text{mol/mg protein}$) in Apapa, Makoko and Ibeshe respectively. While in fish liver SOD was 24.82 ± 5.78 , 85.92 ± 7.52 , 91.52 ± 4.44 (U/mg protein), CAT 5.51 ± 0.88 , 3.25 ± 1.52 , 2.76 ± 0.81 (U/mg protein) and MDA 43.41 ± 3.04 , 54.77 ± 16.54 , 56.55 ± 4.02 ($\mu\text{mol/mg protein}$) in Apapa, Makoko and Ibeshe respectively.

Table 1: Heavy metal analysis in muscle and liver of *C. nigrodigitatus*

Station	Metal ($\mu\text{g/g.dw}$)	Muscle	Liver	FAO/WHO 2016
Apapa	Pb	1.57 ± 0.67	2.14 ± 0.99	0.03
	Cd	0.22 ± 0.51	1.51 ± 0.30	
	Cr	0.97 ± 0.55	$2.03\pm0.19^*$	
Makoko	Pb	1.77 ± 0.58	2.08 ± 0.96	
	Cd	0.61 ± 0.26	1.22 ± 0.30	0.03
	Cr	0.95 ± 0.25	1.72 ± 0.35	
Ibeshe	Pb	0.17 ± 0.08	1.19 ± 0.90	
	Cd	0.43 ± 0.22	1.49 ± 0.32	
	Cr	2.38 ± 1.20	$3.67\pm1.03^*$	0.005

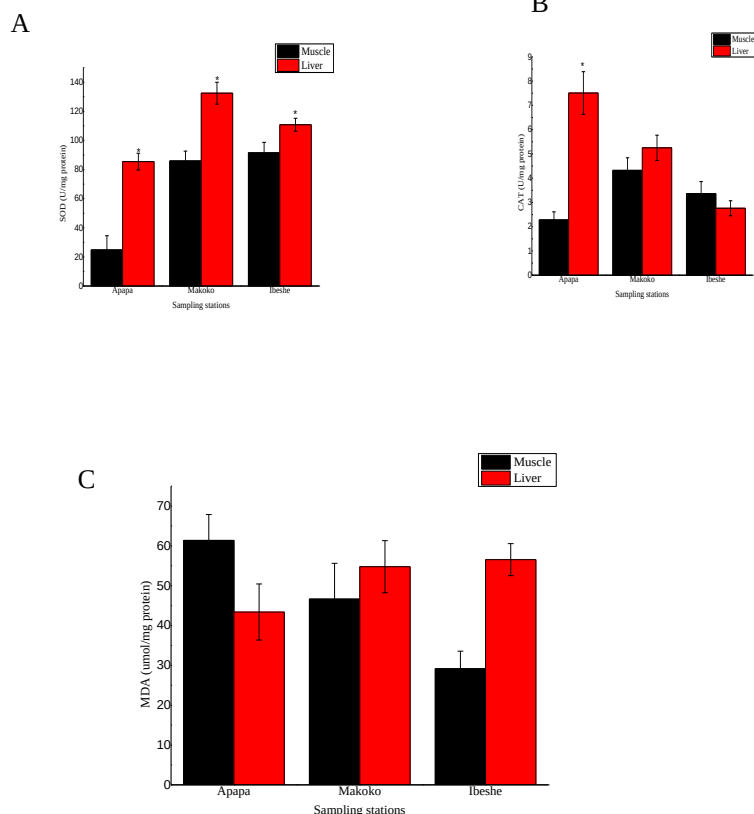


Fig 2. Activities of antioxidant defense enzymes in muscle and liver of *C. nigrodigitatus* in Lagos Lagoon. A: SOD, B: CAT, C: MDA

All values indicate the mean ± standard error of the mean (SEM). Asterisk (*) represents significant difference between muscle and liver

Discussion

Fish accumulates heavy metals within their tissues, which are generally found in the last zone of the aquatic food chain with consequences on human health. Metals are mostly taken up via water and food, distributed by circulation and later accumulated in target organs (Kargin and Çogun 1999). The liver is a metabolically active tissue as such it can easily accumulate high levels of heavy metals (Aytekinet *et al.*, 2019; Ajani *et al.*, 2020). The high concentrations of Pb, Cd and Cr in the liver compared to muscle tissue may be attributed to the level of metal binding protein metallothionein in the liver (Gorur, *et al.*, 2012). Most studies have reported that liver metal content is high when compared to muscle tissue (Cogunet *et al.*, 2005; Nabayiet *et al.*, 2012; Aytekinet *et al.*, 2019). The liver represents a filter detoxifying by storing heavy metals. High metal accumulation capabilities make the liver the most important target and storage tissue in aquatic organisms (Jezierska and Witeska 2006; Aytekinet *et al.*, 2019).

Fish muscles are mainly edible parts, but the muscles are not the tissues where heavy metals are accumulated. The lower levels being in the muscle reflected its lower affinity to metals in their habitat. Generally, the order of heavy metal concentrations in muscle was Cr > Pb > Cd and liver Cr > Pb > Cd. Chromium levels were significantly increased in both muscle and liver at Ibeshe. High levels of chromium alter the metabolic activities of fish.

In this study, the higher amounts of heavy metals in muscle and liver of this fish induces variations in biochemical responses of antioxidant enzymes. Superoxide dismutase (SOD) and catalase (CAT) activities were significantly higher in liver as compared to the muscle. The increase in ROS generation has been shown to induce antioxidant enzyme activities due to increased metal exposures (Ajani *et al.*, 2021). This is because the SOD-CAT system is the first line of defense against oxidative stress, as such both enzymes increase accordingly in response to stressors. The level of malondialdehyde (end product of lipid peroxidation) was relatively higher in liver but the highest level was recorded in muscle. This may be related to increased reactive oxygen species (ROS) formation, which will eventually activate oxidative stress (Arojojoye *et al.*, 2018; Ajani, 2020). In extreme cases, this can alter the structure and function of macromolecules like DNA, cell disruption, cancer and cell death (Stevens *et al.*, 2012;

Arojojoye *et al.*, 2018). The observed increased in lipid peroxidation in the muscle is similar to reports of Farombi *et al.*, 2007 that demonstrated a significantly higher malondialdehyde levels in organs of fish from Ogun River; and an elevated lipid peroxidation in muscle of fish species inhabiting Lagos Lagoon was reported by Ajani, 2020.

The sampling stations have significant human activities that may promote heavy metal exposures in the Lagos Lagoon. Apapa is associated with marina operations that involves transportation and storing of petroleum products, Makoko has a sawmill industry and Ibeshe has a textile industry. In this study, the levels of metals determined by fish can suggest the intensities of human activities in these sampling stations. The result indicates that the heavy metal contamination definitely affects the aquatic life. Hence, the need for the development of a detoxification strategy to improve the health of this economic fish in any stressed habitat.

Conclusion

The ecological needs of *C. nigrodigitatus* determine the level of metal content in its tissues. The result showed that the concentrations of heavy metals varied among the tissues and liver has a higher metal load as compared to the muscle. Also, activities of antioxidant defense enzymes are higher in liver than the muscle and possibility of oxidative injury due to lipid peroxidation in the muscle. Generally, human activities in sampling stations may enhance the concentrations of heavy metals in the Lagos Lagoon. Presence of metals in fish muscle especially Pb and Cr, with values higher than international health organization may be detrimental to human health, as such attention should be taken regarding intake of this fish.

References

- Abdel-Gawad F.K., Guerriero G., Khalil W.K.B. and Abbas H.H. 2016 Evaluation of oxidative stress, genotoxicity and gene expression alterations as oil pollution markers in *Solea vulgaris* from Suez Canal. *Quantum Matter* 5(2):291–296
- Ajani, G.E. 2020. Biomarker profile of silver catfish *Chrysichthys nigrodigitatus* in heavy metal polluted areas of the Lagos Lagoon. *Proceedings of the Nigeria Academy of Science*. Themed Edition on Sustainable Development Goal 14 Volume 13, No 2: 15-35.
- Ajani, G.E., Popoola, S.O. and Oyatola, O.O. 2021. Evaluation of the pollution status of Lagos coastal waters and sediments using physicochemical characteristics, contamination factor, Nemerow pollution index, Ecological Risk and potential Ecological Risks index. *International journal of Environment and Climate Change*, 11:1-16.
- Arojojoye, O.A., Oyagbemi, A.A. and Afolabi, J.M. 2018. Toxicological assessment of heavy metal bioaccumulation and oxidative stress biomarkers in *Clarias gariepinus* from Igboko River of south western, Nigeria. *Bulletin Of Environmental Contamination and Toxicology*, 100:765-771.
- Aytekin, T. Kargim, D. and Kargin, F. 2019. Accumulation and health risk assessment of heavy metal in tissues of the shrimp and fish species from the Yumurtalik coast of Iskenderun, Gulf, Turkey. *Heliyon* 5e02131.
- Buege, J. and Aust, S. 1978. Microsomal lipid peroxidation. *Methods in Enzymology* 52: 302-310.
- Carpenter, K.E. and De Angelis, N. 2016. The living marine resources of the Eastern Central Atlantic, Volume 2: Bivalves, gastropods, langoustines, sharks, batoid fishes, and chimaeras. *FAO Species Identification Guide for Fishery Purposes, Rome, FAO*. pp. 665- 1509.
- Cogun, H.Y., Yuzeroglu, T.A., Kargin, F. and Firat, E.O. 2005. Seasonal variation and tissue distribution of heavy metals in shrimp and fish species from the Yumurtalik coast of Iskenderun gulf, Mediterranean. *Bulletin of Environmental Contamination and Toxicology*, 75:707–715
- Eroglu A., Dogan Z., Kanak E.G., Atli G. and Canli M. 2015. Effects of heavy metals (Cd, Cu, Cr, Pb, Zn) on fish glutathione metabolism. *Environmental Science Pollution Research International* 22:3229–3237.
- Farombi, E.O., Adelowo, O.A. and Ajimoko, Y.R. 2007. Biomarkers of oxidative stress and heavy metal levels as indicators of environmental pollution in African Cat Fish (*Clarias gariepinus*) from Nigeria Ogun River. *International Journal of Environmental Research and Public Health* 4(2):158–165
- Food and Agricultural Organization (FAO)/Swedish International Development Cooperation Agency (FAO/SIDA), 1983. Manual of methods in aquatic environmental research, part 9. Analyses of metals and organochlorines in fish. FAO Fisheries. *Technical paper* 212pp.
- Food and Agricultural Organization (FAO)/World Health Organization (FAO/WHO), 2016. Guidelines and Standards for aquatic habitat. *Technical paper* 320pp.
- Gorur, F.K., Keser, R., Akcay N. and Dizman, S. 2012. Radioactivity and heavy metal concentrations of some commercial fish species consumed in the Black Sea Region of Turkey. *Chemosphere* 87:356.

- Jezierska, B. and Witeska, M. 2006. The metal uptake and accumulation in fish living in polluted waters, in: soil and water pollution monitoring, protection and remediation, *Journal of Biological Science* 8: 107–114pp.
- Kargin, F., and Çogun, H.Y. 1999. Metal interactions during accumulation and elimination of zinc and cadmium in tissues of the freshwater fish *Tilapia nilotica*. *Bulletin of Environmental Contamination and Toxicology*, 63:511–519.
- Kingston, H. and Jassie, L. 1988. Introduction to microwave sample preparation. *American Chemical Society* 54.
- Magwere, T., Naik, Y. and Hasler, J. 1997. Effect of chloroquine treatment on antioxidant enzymes in rat liver and kidney. *Free Radical and Biological Medicine* 22:321-327.
- Nabavi, S.F., Nabavi, S.M., Latifi, A.M., Eslami, M.A. and Ebrahim Z. 2012. Determination of trace elements level of pikeperch collected from the Caspian Sea. *Bulletin of Environmental contamination and Toxicology*, 88:401–405.
- Okay OS, Ozmen M, Güngördü A, Yilmaz A, Yakan SD, Karacik B, Tutak B., and Schramm K.W. 2016. Heavy metal pollution in sediments and mussels: assessment by using pollution indices and metallothionein levels. *Environmental Monitoring and Assessment*, 188:352
- Segbeloyin, J.N., Onyimonyi, A.E., Ujam, O.T., Ukwueze, N.N. and Ukoha, P.O. 2010. Assessment of toxic trace metals in selected fish species and parts of domestic animals. *Pakistan Journal of Nutrition* 9:213-215.
- Sinha, A.K. 1972. Colorimetric assay of catalase. *Analytical Biochemistry* 47:389-394.
- Smith, M.P.L. 1985. Effects of observer swimming speed on sample counts of temperate rocky reef fish assemblages. *Marine Ecology Progress Series* 43:223-231.
- Stevens, J.J., Graham B., Walker A.M., Tchounwou, P.B. and Rogers C. 2010. The effects of arsenic trioxide on DNA synthesis and genotoxicity in human colon cancer cells. *International Journal of Environmental Research and Public Health* (5):2018–2032.

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Comparative study on heavy metal concentrations and biochemical responses in *Chrysichthys nigrodigitatus* and *Sardinella maderensis* from Lagos Lagoon

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Abstract

This study evaluated the heavy metal levels in muscles of commercial fishes *Chrysichthys nigrodigitatus* and *Sardinella maderensis* inhabiting Lagos Lagoon, Nigeria. Biomarkers of oxidative stress were determined in both fishes across three sampling stations. There was significant increase in the concentrations of heavy metal in *C. nigrodigitatus* as compared to *Sardinella maderensis*. There was increase antioxidant defense enzymes activities in *C. nigrodigitatus* as compared to *Sardinella maderensis*. This may be related to their feeding habits which promotes metal accumulation, resulting in increased antioxidant enzyme activities. These results show that Lagos Lagoon is polluted and consumption of fish from this water may be unsafe for humans.

Keywords: Heavy metals, *Chrysichthys nigrodigitatus*, *Sardinella maderensis*, oxidative stress, Lagos Lagoon

Introduction

Aquatic habitats are mostly polluted with a wide range of contaminants and these have generated a great concern over the last few decades (Okay *et al.*, 2016; Arojojoye *et al.*, 2018; Ajani, *et al.*, 2021). Anthropogenic pressures from domestic and industrial activities along the coastlines have extensively polluted the aquatic environments with heavy metals. Pollution of these waterways may have negative impact on ecosystem structure and functions (Farombi, *et al.*, 2007; Ajani, 2020). Aquatic species like fish inhabits these polluted habitats and are mostly affected. Fish represents bioindicators that can be used to evaluate the physiological status of an aquatic ecosystems (Eroglu *et al.*, 2015). Hence, high concentrations of metal in tissues, may result in the generation of reactive oxygen species (ROS), which are considered as a major inducer of oxidative stress. These organisms have the capacity to develop strategies to reduced the impacts these oxidants by responding via the induction of antioxidant defense systems (Eroglu *et al.*, 2015; Abdel-Gawad *et al.*, 2016; Ajani, 2020). Some of the antioxidant enzymes are superoxide dismutase (SOD), catalase (CAT), and the glutathione triad: reduced glutathione (GSH), glutathione S-transferase (GST) and glutathione peroxidase (GPx). These enzymes have unique roles of detoxifying the ROS species (Farombi *et al.*, 2007; Ajani, 2020). The Lagos Lagoon has been impacted with different effluents due to coastal activities resulting in high volume of contaminants, suspended and solids molecules and nutrients (Nkwoji *et al.*, 2020). Despite the economic and fisheries importance of *C. nigrodigitatus* and *S. maderensis* a comparative study of their metal content in relation to biochemical responses in Lagos Lagoon is elusive. Hence, heavy metal concentrations and activities of antioxidant defense enzymes in fish muscle are analysed.

Materials and Methods

One hundred and ninety-two *C. nigrodigitatus* (CN) (Apapa n=61, Makoko n=83 and Ibeshe n=48) with average weight of 180g and two hundred and thirty *S. maderensis* (SM) (Apapa n=77, Makoko n=98 and Ibeshe n=55) with average weight of 25g and were caught from three sampling stations (Fig 1). Fish was dissected and one gram of muscle and liver was removed. The tissues were placed in a Teflon beaker and digested in an acid solution (HNO₃) in preparation for heavy metal analysis (Kenstar closed vessel microwave digestion) using the microwave digestion procedure (Segbeloyin *et al.*, 2010). The specimens were digested with 5 milliliters of HNO₃ (65%) and filtered with the Whatman Filter Paper no 41 into a 25 milliliters volumetric flask and made up to mark with distilled water (FAO/SIDA, 1983). All digested specimens were analysed in triplicates for the following metals: lead, cadmium and chromium were analysed in muscle and liver by atomic absorption spectrometry using atomic absorption spectrophotometer (Perkin-Elmer AA 700). The equipment was graded with standard solutions formulated from economically available chemicals purchased from Merck KGaA, Germany (Kingston and Jassie, 1988). The antioxidant defense enzyme analysis involves the removal of muscle and liver tissue from fish and washed in ice-cold 0.65 percent sodium chloride before storage. 0.5 gram of tissue was homogenized with five milliliters of 0.4M phosphate buffer using Teflon homogenizer. The tissue homogenates were centrifuged at 3000rpm at 15mins. The

resulting supernatant was used for further biochemical analysis (Magwere *et al.*, 1997). Superoxide Dismutase (SOD) activity evaluated using procedures from Magwere *et al.*, (1997). Catalase (CAT) activity followed procedures from Sinha (1972). Malondialdehyde (MDA) constitute part of the final output of lipid peroxidation. MDA levels was analysed according to Buege and Aust (1978) methods. The total protein estimation was measured with Bicinchoninic Acid (BCA) procedure (Smith *et al.*, 1985). All values for the results are expressed as mean±standard error. Unpaired student t-test was used to determine significant differences ($p < 0.05$) in heavy metal concentrations and antioxidant activities in muscle and liver using Origin 8. All values were considered statistically significant at $P < 0.05$.



Figure 1: Map of Lagos Lagoon showing sampling stations

Results

Heavy metal levels in CN include; Pb was 1.57 ± 0.67 , 1.77 ± 0.58 and 0.17 ± 0.08 , Cd was 0.22 ± 0.51 , 0.61 ± 0.26 , 0.43 ± 0.22 , Cr was 0.97 ± 0.55 , 0.95 ± 0.25 , 2.38 ± 1.20 $\mu\text{g/g.dw}$, respectively, in Apapa, Makoko and Ibeshe respectively. The results indicate that lead and chromium levels was relatively higher than other metals (Table 1). For SM metal levels include; Pb was 0.19 ± 0.07 , 1.08 ± 0.26 and 0.19 ± 0.08 , Cd was 0.71 ± 0.25 , 0.22 ± 0.17 , 0.29 ± 0.13 , Cr was 0.40 ± 0.09 , 0.72 ± 0.12 , 1.67 ± 1.05 $\mu\text{g/g. dw}$, respectively, in Apapa, Makoko and Ibeshe respectively. The activities of antioxidant defense enzymes were analysed in CN muscle SOD was 85.96 ± 9.75 , 132.37 ± 6.75 , 110.78 ± 7.16 (U/mg protein), CAT 2.28 ± 0.33 , 4.32 ± 2.52 , 3.36 ± 1.56 (U/mg protein) and MDA 61.39 ± 14.5 , 46.65 ± 10.98 , 29.15 ± 4.41 ($\mu\text{mol/mg protein}$) in Apapa, Makoko and Ibeshe respectively. While in fish SM muscle SOD was 89.0 ± 2.90 , 86.0 ± 7.52 , 114.70 ± 1.84 (U/mg protein), CAT 2.81 ± 0.21 , 4.68 ± 0.84 , 2.76 ± 0.11 (U/mg protein) and MDA 26.50 ± 4.02 , 34.01 ± 6.80 , 35.50 ± 3.26 ($\mu\text{mol/mg protein}$) in Apapa, Makoko and Ibeshe respectively.

Table 1: Heavy metal analysis in muscles of *C. nigrodigitatus* (CN) and *S. maderensis*(SM) in Lagos Lagoon

Stations	Metal ($\mu\text{g/g.dw}$)	CN	SM	FAO 2016
Apapa	Pb	1.57 ± 0.67	0.19 ± 0.19	0.03
	Cd	0.22 ± 0.51	0.71 ± 0.25	
	Cr	0.97 ± 0.55	0.40 ± 0.09	
Makoko	Pb	1.77 ± 0.58	1.08 ± 0.26	
	Cd	0.61 ± 0.26	0.22 ± 0.17	0.03
	Cr	0.95 ± 0.25	0.72 ± 0.30	
Ibeshe	Pb	0.17 ± 0.08	0.19 ± 0.30	
	Cd	0.43 ± 0.22	0.29 ± 0.13	
	Cr	2.38 ± 1.20	1.67 ± 1.05	0.005

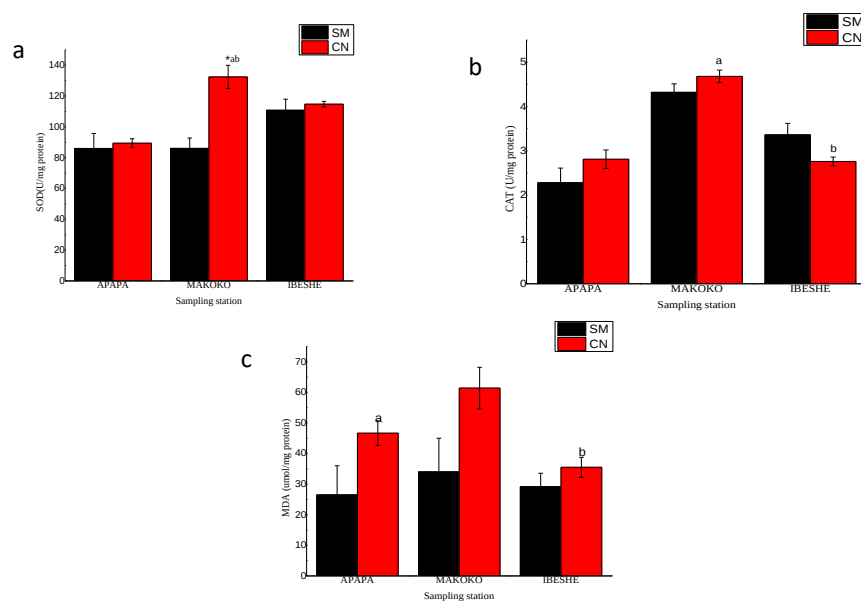


Fig 2. Activities of antioxidant defense enzymes in *C. nigrodigitatus* and *S. maderensis* from Lagos Lagoon. A: SOD, B: CAT C: MDA. All values indicate the mean±standard error of the mean (SEM). Asterisk (*) represents significant difference between CN and SM

Discussion

Fish accumulates heavy metals within their tissues, which are generally found in the last zone of the aquatic food chain with consequences on human health. Metals are mostly taken up via water and food, distributed by circulation and later accumulated in target organs (Kargin and Çogun 1999; Aditeet *et al.*, 2017). The present study shows elevated concentrations of metal in *C. nigrodigitatus* muscle (CN). This may probably be as a result of the species feeding habit and trophic nature. This fish exhibits an opportunistic benthic food habit and fed mainly on aquatic insects, benthic invertebrates, detritus, seeds and diatoms (Atobatele and Ugwumba, 2011; Ajani, 2020). The wide array of food items promotes metal accumulation. The lower metal levels in *S. maderensis* being reflects the trophic nature and feeding habits. This fish is a pelagic fish that feeds on crustaceans and phytoplankton which accumulates low level of metals (Baaliet *et al.*, 2020). Generally, the order of heavy metal concentrations in *C. nigrodigitatus* was Cr > Pb > Cd and SM Cr > Cd > Pb. Chromium levels was significantly increased in both fish species at Ibeshe. Odjegba and Bangbose, 2012 reported a high levels of Cr in sediments receiving point discharge of textile factory effluent indicating that dyeing process usually contributes some heavy metals like Cr, Pb, Zn and Cu to wastewaters. High level of chromium alters the metabolic activities of fish (Ajani, 2020). In this study, the higher amounts of heavy metals in muscle of these fish induces variations in biochemical responses of antioxidants enzymes. Superoxide dismutase (SOD) and catalase (CAT) activities were significantly higher in *C. nigrodigitatus* compared to SM. The increase ROS generation has been shown to induce antioxidant enzymes activities due to increased metal exposures (Ajani *et al.*, 2021). This is because SOD-CAT system is the first line of defense against oxidative stress, as such both enzymes increase accordingly in response to stressors. The level of malondialdehyde (end product of lipid peroxidation) was relatively higher in *C. nigrodigitatus* and this may be related to increased reactive oxygen species (ROS) formation, which will eventually induce oxidative stress (Arojoye *et al.*, 2018; Ajani, 2020). In extreme cases, this can alter the structure and function of macromolecules like proteins, DNA, cell disruption, cancer and cell death (Stevens *et al.*, 2012; Arojoye *et al.*, 2018). The observed increase in lipid peroxidation in both fishes is similar to reports of Farombi *et al.*, (2007); Arojoye *et al.*, 2018; Ajani, (2020).

The sampling stations have significant human activities that may promote heavy metal exposures in the Lagos Lagoon. In this study, the levels of metals determined by fish can suggest the intensities of human activities in these sampling stations. The result indicates that the heavy metal contamination definitely affects the aquatic life fish. Hence, the need for the development of a biotransformation mechanism to improve the health of this economic fish in any stressed habitat.

Conclusion

The ecological needs of *C. nigrodigitatus* and *S. maderensis* determine the level of metal content in their tissues. The result showed that the concentrations of heavy metals and antioxidant enzyme activities varied among the fish species. This suggests the trophic status and feeding habits may promote accumulation of metals. The presence of metals in fish muscle especially Pb and Cr, with values higher than international health organization may be detrimental to human health, as such attention should be taken regarding intake of these fishes.

References

- Abdel-Gawad, F.K., Guerriero, G., Khalil, W.K.B and Abbas, H.H. 2016. Evaluation of oxidative stress, genotoxicity and gene expression alterations as oil pollution markers in *Solea vulgaris* from Suez Canal. *Quantum Matter* 5(2):291–296
- Adite, A., Gbaguidi, H and Ibikounle, M. 2017. Growth patterns and Fulton's condition factor of the silver catfish *Chrysichthys nigrodigitatus* from a man-made lake from Benin. *African Journal of Agricultural Science*, 12:2283-2294.
- Ajani, G.E. 2020. Biomarker profile of silver catfish *Chrysichthys nigrodigitatus* in heavy metal polluted areas of the Lagos Lagoon. *Proceedings of the Nigeria Academy of Science*. Themed Edition on Sustainable Development Goal 14 Volume 13, No 2: 15-35.
- Ajani, G.E., Popoola, S.O. and Oyatola, O.O. 2021. Evaluation of the pollution status of Lagos coastal waters and sediments using physicochemical characteristics, contamination factor, Nemerow pollution index, Ecological Risk and potential Ecological Risks index. *International Journal of Environment and Climate Change*, 11:1-16.
- Arojoye, O.A., Oyagbemi, A.A. and Afolabi, J.M. 2018. Toxicological assessment of heavy metal bioaccumulation and oxidative stress biomarkers in *Clarias gariepinus* from Igboko River of south western, Nigeria. *Bulletin of environmental contamination and Toxicology*, 100:765-771.
- Baali, A, Quazzani, K. and Amanzoni, K. 2020. Diet composition of round *Sardinella aurita* and flatfish *Sardinella maderensis* of Atlantic Moroccan coast. *Egyptian Journal of Aquatic Biology*. 24:73-91
- Buege, J. and Aust, S. 1978. Microsomal lipid peroxidation. *Methods in Enzymology* 52: 302-310.
- Carpenter, K.E. and De Angelis, N. 2016. The living marine resources of the Eastern Central Atlantic, Volume 2: Bivalves, gastropods, anguilliforms, sharks, batoid fishes, and chimaeras. *FAO Species Identification Guide for Fishery Purposes, Rome, FAO*. pp. 665- 1509.
- Cogun, H.Y., Yuzeroglu, T.A., Kargin, F. and Firat, E.O. 2005. Seasonal variation and tissue distribution of heavy metals in shrimp and fish species from the Yumurtalik coast of Iskenderun gulf, Mediterranean. *Bulletin of Environmental Contamination and Toxicology*, 75:707–715
- Eroglu A., Dogan Z., Kanak E.G., Atli G., and Canli M. 2015. Effects of heavy metals (Cd, Cu, Cr, Pb, Zn) on fish glutathione metabolism. *Environmental Science Pollution Research International* 22(5):3229–3237.
- Farombi EO, Adelowo OA, Ajimoko YR 2007. Biomarkers of oxidative stress and heavy metal levels as indicators of environmental pollution in African Cat Fish (*Clarias gariepinus*) from Nigeria Ogun River. *International Journal Environmental Research and Public Health* 4(2):158–165
- Food and Agricultural Organization (FAO)/Swedish International Development Cooperation Agency (FAO/SIDA), 1983. Manual of methods in aquatic environmental research, part 9. Analyses of metals and organochlorines in fish. FAO Fisheries. *Technical paper* 212pp.
- Food and Agricultural Organization (FAO)/World Health Organization (FAO/WHO), 2016. Guidelines and Standards for aquatic habitat. *Technical paper* 320pp.
- Kargin, F., and Cogun, H.Y. 1999. Metal interactions during accumulation and elimination of zinc and cadmium in tissues of the freshwater fish *Tilapia nilotica*. *Bulletin of Environmental Contamination and Toxicology*, 63:511–519.
- Kingston, H. and Jassie, L. 1988. Introduction to microwave sample preparation. *American Chemical Society* 54.
- Magwere, T., Naik, Y. and Hasler, J. 1997. Effect of chloroquine treatment on antioxidant enzymes in rat liver and kidney. *Free Radical and Biological Medicine* 22:321-327.
- Nkwoji, J.A., Ugbana, S. and Ina-Salwany, M.N. 2020. Impacts of land-based pollutants on water chemistry and benthic invertebrates community of Lagos Lagoon. *Scientific African* 7:e00220.
- Odjegba, V.J. and Bamgbose, N.M. 2012. Toxicity assessment of treated effluents from a textile industry in Lagos, Nigeria. *African Journal of Environmental Science and Technology* 6:438-445.
- Okay, O.S., Ozmen, M., Güngördü, A., Yilmaz A., Yakan S.D., Karacik B., Tutak B. and Schramm K.W. 2016. Heavy metal pollution in sediments and mussels: assessment by using pollution indices and metallothionein levels. *Environmental Monitoring and Assessment*, 188:352

- Segbeloyin, J.N., Onyimonyi, A.E., Ujam, O.T., Ukwueze, N.N. and Ukoha, P.O. 2010. Assessment of toxic trace metals in selected fish species and parts of domestic animals. *Pakistan Journal of Nutrition* 9:213-215.
- Sinha, A.K. 1972. Colorimetric assay of catalase. *Analytical Biochemistry* 47:389-394.
- Smith, M.P.L. 1985. Effects of observer swimming speed on sample counts of temperate rocky reef fish assemblages. *Marine Ecology Progress Series* 43:223-231.
- Stevens J.J., Graham B., Walker A.M., Tchounwou P.B. and Rogers C. (2010) The effects of arsenic trioxide on DNA synthesis and genotoxicity in human colon cancer cells. *International Journal Environmental Research and Public Health* 7(5):2018–2032.

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Heavy Metal Tolerance (Cadmium, Chromium and Nickel) In Bacteria Isolated From Shellfishes**Oramadike C.E., Agwu O.A., Bello B.O., And Olajuyigbe O. O.**

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Abstract

To further understand the implication of the elevated heavy metals concentrations on shellfish muscles above the permissible limit by WHO/FAO and UNEP, this study analyzed the heavy metal tolerance of Cadmium (Cd), Chromium (Cr) and Nickel (Ni) by bacteria from these shellfishes (Crab, Tiger shrimp and pink shrimp). The 16S rRNA (16S ribosomal RNA) sequencing and their basic local alignment search tool search analysis of the six bacterial isolates identified three (CBV4, CBV10 and SBV5) as *Pseudomonas aeruginosa*, two (SBV1 and SBV7) as *Proteus vulgaris* and one (SAV9) as *Alcaligenes faecalis*. The tolerance of the isolates to the heavy metals varied as the extent of growth decreased with increasing metal concentration. Nevertheless, the least tolerance was observed for Cd, as no growth was noted above 5.0 µg /mL contrary to growth at 15.0 and 25.0 µg /mL for Cr and Ni respectively. The *Pseudomonas aeruginosa* (CBV4) isolated from crab exhibited an outstanding tolerance to high concentrations of all the heavy metals tested. The heavy metal tolerance of these bacteria isolates from shellfish muscles with high heavy concentration further suggests heavy metal contamination of the shellfish habitat waterbody.

Keywords: Heavy metal, Tolerance, shellfish, Bacteria

Introduction

Heavy metals are defined as a group of metals whose atomic density is greater than 5 grams per cubic centimetre, relatively high levels of these metals occur naturally in the environment and we have about fifty heavy metals in nature (Hossain and Anwar, 2012). The study of heavy metals contamination in food and environment is of special concern because of their toxicological effect on human beings, animals and other living organisms e.g microorganisms (Bruins *et al.*, 2000). They persist in nature and consequently tend to accumulate in food chains. Shellfishes are known benthic feeders and they are chosen as biomarkers for studies in aquatic environments because they are good bio-indicator of pollutants in an aquatic environment (Farkas *et al.*, 2002). The distribution of heavy metals varies among fish species depending on age, development status and other physiological factors (Adams, 2002). Furthermore, the tolerance of microorganisms to heavy metals has been proposed as an indicator of the potential toxicity of heavy metals in the environment where the organism was isolated (Lima e Silva, et al., 2012). Therefore, there is a dramatic increase in the interest in studying the interactions of heavy metals with microorganisms. The presence of bacteria in the muscles of shellfishes with relatively high concentration of some heavy metals prompted a study of the heavy metal tolerance of these microorganisms hence the objective of this study was to analyze the heavy metal tolerance (chromium, cadmium and Nickel) of these bacteria from shellfishes to further highlight the implications of these contaminants in the food chain and environment in general.

Materials and Methods**Sample collection**

Fresh seafood samples, crab (*Callinectes amnicola*), Tiger shrimp (*Penaeus monodon*) and pink shrimp (*Penaeus notialis*) were purchased from Fishmarket/landing site in Makoko, Lagos State, Nigeria, located between longitudes 3° 23' and 3° 39' E and Latitudes 6° 23' and 6° 44' N, by aseptically random picking into sterilized containers using hand gloves. These were placed in an iced pack and transported to the fish technology department Microbiology Laboratory of Nigerian Institute for Oceanography and Marine Research, Victoria Island within 2 h of collection for proper identification, microbiological analyses and other laboratory analysis.

Isolation and Identification of bacteria

The standard microbiological isolation of pour plate method on Tryptone soy agar (TSA) plates was used to isolate the bacteria strains from the fish muscles. These were further purified and were subjected to molecular identification using the method of Omoya and Ajayi, (2020).

Evaluation of heavy metal tolerance

Sample preparation was made by modifying the method described by Oluwagunke *et al.* (2020). The heavy metals chosen were selected according to previous experiments with the shellfishes (data not shown). The microbial growth was used to determine the tolerance pattern of the isolated organisms to Cd (Fisher scientific), Cr and Ni (AccStandard). This was done by growing the bacteria isolates in nutrient agar mixed with an increasing concentration of metals. For this test, 10 different concentrations namely 0.5, 1.0, 5.0, 10.0, 15.0, 20.0, 25.0, 30.0 µg/mL of heavy metal (Cd, Cr and Ni) was prepared filter sterilized through 0.2 µm pore size sterile membrane filters and dispensed into the sterile nutrient agar. The inoculated tubes were incubated at 28°C for 24 h. This arbitrary procedure was employed to define metal tolerant bacteria were able to multiply in the media within 24h in the presence of the chosen metal concentrations.

Results

The Six (6) isolates for this study were molecularly identified as *Pseudomonas aeruginosa*(CBV4), *Pseudomonas aeruginosa*(CBV10) from the crab; *Proteus vulgaris* (SBV1), *Pseudomonas aeruginosa*(SBV5) and *Proteus Vulgaris* (SBV7) from the Tiger shrimp and *Alcaligenes faecalis*(SAV9) from the pink shrimp(Table1).

Table 1. Bacterial isolates from the shellfishes and their identification

Shellfishes	Isolate codes	Identification
Crab (<i>Callinectes amnicola</i>)	CBV4	<i>Pseudomonas aeruginosa</i>
	CBV10	<i>Pseudomonas aeruginosa</i>
Tiger shrimp (<i>Penaeus monodon</i>)	SBV1	<i>Proteus vulgaris</i>
	SBV5	<i>Pseudomonas aeruginosa</i>
	SBV7	<i>Proteus vulgaris</i>
Pink shrimp (<i>Penaeus notialis</i>)	SAV9	<i>Alcaligenes faecalis</i>

The tolerance of all the bacteria isolates to the heavy metals Cd, Cr and Ni decreased with increasing concentrations (Table 2, 3 and 4). It was noted that four of the isolates CBV4, SBV1, SBV5 and SBV7 tolerated high concentration of Cd (5.0µg /mL). Similarly, CBV4, CBV10, SBV5 and SAV9 were able to grow at 25.0µg /mL of Cr. On the other hand, while only two isolates *Pseudomonas aeruginosa*(CBV4) and *Proteus vulgaris* (SBV7) exhibited the highest tolerance of Ni to about 25.0µg /mL. It is noteworthy that *Pseudomonas aeruginosa*(CBV4) isolated from crab exhibited high tolerance to all the metals tested.

Table 2. Heavy metal Cadmium tolerance profile of selected bacterial isolates

Isolate code	Growth on Nutrient agar	Growth (tolerance) at various µg /mL		
		0.5	1.0	5.0
CBV4	+++	+++	+++	+++
CBV10	+++	+++	+++	-
SBV1	+++	+++	+++	+++
SBV5	+++	+++	+++	+++
SBV7	+++	+++	+++	+++
SAV9	+++	+++	+++	-

Note: + = Positive (+ = scanty, ++ = moderate, +++ = heavy), - = Negative

Table 3. Heavy metal Chromium tolerance profile of selected bacterial isolates

Isolate code	Growth on Nutrient agar	Growth (tolerance) at various µg /mL				
		0.5	1.0	5.0	10.0	15.0
CBV4	+++	+++	+++	+++	+++	+
CBV10	+++	+++	+++	+++	+++	+
SBV1	+++	+++	+++	+++	+++	-
SBV5	+++	+++	+++	+++	+++	+
SBV7	+++	+++	+++	+++	+++	-
SAV9	+++	+++	+++	+++	+++	+

Note: + = Positive (+ = scanty, ++ = moderate, +++ = heavy), - = Negative

Table 4. Heavy metal Nickel tolerance profile of selected bacterial isolates

Isolate code	Growth on Nutrient agar	Growth (tolerance) at various µg /mL						
		0.5	1.0	5.0	10.0	15.0	20.0	25.0
CBV4	+++	+++	+++	+++	+++	++	+	+
CBV10	+++	+++	+++	+++	+++	+	-	-
SBV1	+++	+++	+++	+++	+++	+	-	-
SBV5	+++	+++	+++	+++	+++	++	-	-
SBV7	+++	+++	+++	+++	+++	++	+	+
SAV9	+++	+++	+++	+++	+++	+	-	-

Note: + = Positive (+ = scanty, ++ = moderate, +++ = heavy), - = Negative

Discussion

Heavy metal accumulation in the food chain and environment is presently trending due to the health challenge to human and the entire ecosystem. The bacteria in this study isolated from the shellfish muscles with high concentrations of heavy metals showed reasonable tolerance to Cr, Cd and Ni. This result compares favorably with the report of Bhakta et al. (2012), who indicated *E. faecium* metal tolerate organism from fish caught from heavy metal polluted water body. According to Oluwagunke *et al.* (2020), most bacteria from heavy metal polluted waterbody exhibit higher metal tolerance. Also, the least tolerance to Cd concentration (5.0µg /mL) out of the three metals noted in the present study suggests that there may be no intense cadmium pollution in the environment or the water body where the shellfishes were caught. Cadmium is a serious pollutant, it enters into the body of animals and humans through the food chain and causes various diseases (Bhaktar et al., 2012). Bacteria tolerance to Cr was a little high in this present work, the *Pseudomonas* strains notably thrived well at very high concentration of Cr this corroborated with a similar report by Hossain and Anwar, (2012). The high tolerance to Ni observed in this study is also comparable to the tolerance of microorganisms to nickel up to 24 mM concentration as reported by Chaudhary *et al.* (2017). In conclusion, the remarkable tolerance exhibited by these bacteria strains further suggest high contamination of the aquatic habitat of the shellfishes.

References:

- Adams, S. M. (2002). Biological indicators of aquatic ecosystem stress: Introduction and overview. *In Biological Indicators of Aquatic ecosystem Stress*. American Fish Society Bethesda Maryland. 1-11.
- Bhakta J.N., MunekageY., Ohnishi K. and Jana B.B. (2012) Isolation and identification of cadmium- and lead-resistant lactic acid bacteria for application as metal removing probiotic Int. J. Environ. Sci. Technol. 9:433-440.
- Bruins M. R., Kapal S. and Oehme W. F. (2000). Microbial resistance to metals in the environment. *Ecotoxocol Environ Safety*. 45:198-207.
- Chaudhary A., Shirodkar S. and Sharma A. (2017) Characterization of Nickel Tolerant Bacteria Isolated from Heavy Metal Polluted Glass Industry for its Potential Role in Bioremediation, Soil and Sediment Contamination: An International Journal, 26:2, 184-194.
- Farkas, A. Salanki, J., specziar, A. (2002). Relation between growth and the heavy metal concentration in organs of Bream *Abramisbrama* L. populating Lake Balaton. *Archives of Environmental contamination and toxicology*. 43 (2):236-243.

- Hossain M. I. and Anwar M. N. (2012). Isolation and Identification of Heavy Metal Tolerant Bacteria from Tannery Effluents. Bangladesh J Microbiol, Volume 29, Number 1, pp 23-26.
- Lima e Silva, A.A., Ribeiro de Carvalho, L de Souza, S.A., Teixeira Dias, P. M., da Silva Filho, R. G., de MeirellesSaramago, C. S., de Melo Bento, C.A., and Hofer, E. (2012). Heavy metal tolerance (cr, ag and hg) in bacteria isolated from sewage. Brazilian Journal of Microbiology. 1620-1631.
- Nwagwu E.C., Yilwa V.M., Egbe N.E. and Onwumere G.B.2017. Isolation and characterization of heavy metal tolerant bacteria from Panteka stream, Kaduna, Nigeria and their potential for bioremediation. *African Journal of Biotechnology*. 16(1): 32-40, 4.
- Oluwagunke, T. O.,Agwu, O. Aand Solagbade, A. M. (2020). Heavy metal tolerance of bacteria from fishes in water bodies close and remote to e-waste dumpsites. Proceedings of 7th NSCB Biodiversity Conference. Pp 98-102.

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Macrobenthic Faunal Changes in the Estuarine Coastal Water of Nigeria: Lagos Lagoon Experience

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Abstract

Macrobenthic organisms are constituents of the aquatic ecosystems with high adaptability to different sediment conditions. This study aimed to evaluate and compare the sensitivity of these organisms to both ecological and anthropogenic activities in the Lagos lagoon. A faunistic survey of sediment samples was collected in triplicates from September 2014 to July 2016 using a van Veen grab (covering an area of 0.1m²). Granulometric characteristics and depth were measured using standard procedures of the British Standards Institute (BSI). Results showed that the evaluated environmental variables with concerns surrounding anthropogenic influences changed with a shift in particle size characteristics from mud to sand. Macrobenthic invertebrate species *Turritella unguina*, *Naticarius hebraeus*, *Macomopsis cumana*, *Pernaperna*, *Spisulatri gonella*, *Senilia senilis*, *Lithophaga lithophaga*, *Galatea paradoxa*, *Solenogaster naicus* were recorded in this study compared to previous works. A noticeable increase in abundances of *Atactodea striata*, *Iphigenia truncate* occurred and a reduction in *Fistulobalanus pallidus*, *Nerita senegalensis* abundances. Therefore, these significant faunal changes are related to the extreme alteration in substrate characteristics due to surrounding anthropogenic influences.

Keywords: Soft-bottom, Fauna, Anthropogenic, Substrate, Ecosystem.

Introduction

Lagoons, estuaries and other water-bodies are important components of the biosphere that play significant roles in habitat provision for diverse plants and animals. They are exposed to diverse anthropogenic activities which cause alterations and modifications of the coastal water ecosystem resulting in ecological changes around the world (Dunne *et al.* 2002; Allesina and Pascal 2008) resulting in shifts in community structure (Coll *et al.* 2008), habitat loss and fragmentation (Elliott and Elliott, 2013; Floehr *et al.*, 2013).

With the recognition of the value of ecosystem services for humans, the role of biodiversity in delivering these services and the awareness that the aquatic ecosystem is the ultimate sink for deposits of pollutants from anthropogenic and natural sources (Edokpayi 2017), there is a growing concern to produce reliable projections of the effects of human interventions on these species habitats and distributions (Diaz and Rosenberg, 2008). The specific objective of the study is to evaluate the present community structure of macroinvertebrates and relate it with previous studies.

Materials and Method

For this study, twenty – four stations (Fig. 1) were selected using Global Positioning System (GPS) - Garmin GPSmap 76 model (Table 1), sampled bi-monthly from September 2014 to July 2016 at the same time hours.

Collection of Sediment Samples and Macroinvertebrates

Sediment samples were collected using a van Veen grab (covering an area of 0.1m²) in triplicates (Longhurst, 1959). A portion of the sample was kept in a well- labelled polythene bag for granulometric analysis (i.e. sand, silt and clay fractions) according to British Standard Institution, (BSI 2016) method. The remaining samples were washed on deck through a sieve of 0.5mm mesh; retained materials (biota) were preserved in 10% formalin (Edmunds, 1978; USEPA, 2001; WSDE, 2008), stored in an ice chest and transported to the laboratory for taxonomic sorting and identification to the lowest possible taxonomic levels.

Particle Size Analysis for Gravel and Sand (%)

The grading and particle size distribution of soil samples was determined using British standard sieves, 2.36 mm, 1.18 mm, 600 microns, 425, 300, 212, 150 and 75 or 63 microns. Lid and receiver, balance readable and accurate to 0.1 gm, drying oven, evaporating pans, sieve brush, mechanical sieve shaker.

Particle Size Sedimentation by Hydrometer Method for Silt and Clay (%)

50 g of the air- dried sediment was ground and introduced into a plastic beaker. 400 cm³ deionized water and 100 cm³ sodium hexametaphosphate solution were added into a beaker, agitated with a stir-rod and emptied into a blender. It was blended for about 30 seconds and poured into a 1000 cm³ graduated cylinder and deionized water

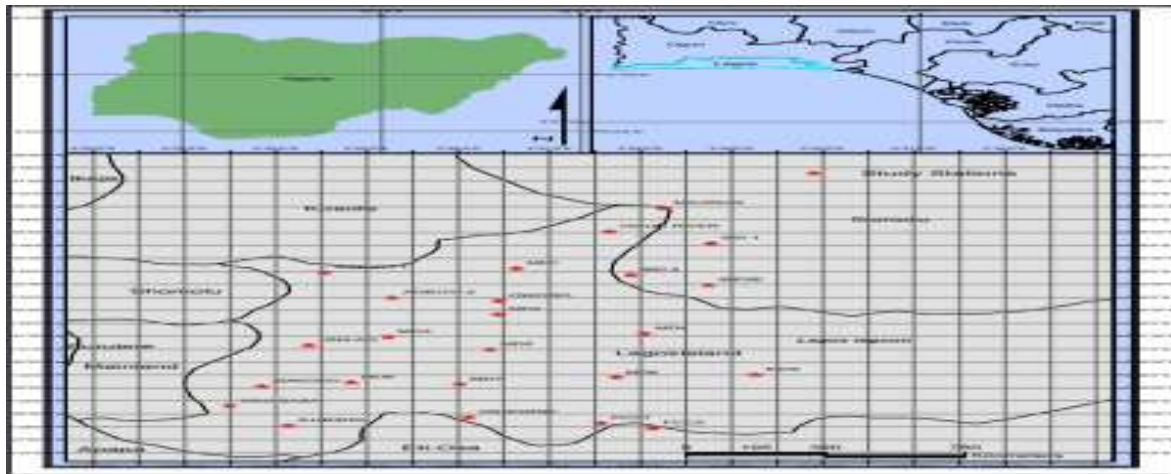


Figure 1: Selected Sampling Stations in Western Lagos Lagoon.

Table 1: Study stations, locations, coordinates and average depths

S/N	Sampled stations name	Coordinates		Average. depths (m)	Anthropogenic activities/ecological interests
		Northings	Eastings		
1	UNILAG	6.518995	3.406172	1.77	university facilities
2	Mid lagoon 3	6.524607	3.420586	0.91	Fishing activities
3	Oworo	6.547671	3.4409	1.13	Sand mining
4	Agboyi 1	6.565877	3.409078	1.25	Sand mining and tributary
5	Agboyi 2	6.55001	3.421475	2.62	Sand mining and settlements
6	Mid lagoon 1	6.568827	3.444125	2.53	Water ways transportation
7	Ogun River	6.592375	3.461128	4.48	Adjoining tributary
8	Majidun	6.607325	3.470942	6.07	Sand mining and tributary
9	Ikorodu 1	6.584928	3.479678	2.68	Port activities, sand mining
10	Ikorodu 2	6.56418	3.465058	2.16	Port activities, sand mining
11	Ibese	6.55783	3.479133	2.49	Jetty, human settlements
12	Mid lagoon 2	6.538965	3.4409	3.66	Pipeline across water way
13	Mid lagoon 4	6.526888	3.467548	3.08	Fishing activities
14	Mid lagoon 5	6.516283	3.439303	3.57	Fishing activities
15	Mid lagoon 6	6.49844	3.462253	3.2	Water ways transportation
16	Five Cowrie Creek1	6.469097	3.459417	2.59	Urban settlements
17	Five Cowrie Creek 2	6.466081	3.469043	2.14	Urban settlement
18	Osborne	6.473108	3.435339	5.67	Urban settlements
19	Ilubirin	6.467364	3.40237	8.29	Land reclamation sites
20	Oko Baba	6.480163	3.391661	4.66	Wood shavings dump site
21	Makoko	6.493004	3.397506	1.16	Fishing activities,
22	Mid lagoon 8	6.49546	3.413878	2.4	Fishing activities
23	Mid lagoon 9	6.50035	3.48789	2.1	High tension poles
24	Mid lagoon 7	6.494157	3.433819	2.4	High tension poles

was added to the graduated cylinder up to the 1000 cm³ mark. The opening of the graduated cylinder was completely covered and inverted a few times to fully suspend the sediment particles. A bouyoucos hydrometer

(Fisher brand *Model 14-331-5c*) was gently added to the sediment suspension and reading was taken 40 seconds after the cylinder inversions ended and were repeated two hours later. Hydrometer readings were taken at the upper rim of the meniscus at time intervals of 0.5 min, 1min, 2 mins and 4 mins. It was observed and the top meniscus reading R_0 was recorded. The hydrometer was reinserted slowly at about 15s in the soil suspension before reading is due and readings were recorded at 8 mins, 30 mins, 2 hrs, 8 hrs and 24 hrs time intervals from the start of sedimentation. The proportion of silt and clay was determined by simple proportion from the hydrometer readings and the original mass of the sediments.

The equivalent particle diameter, D (in mm), was calculated from the equation below:

$$D \text{ (mm)} = 0.005531 \times \frac{\sqrt{\Omega H t}}{(\rho_s - 1) t} \quad (1)$$

Where:

Ω = dynamic viscosity of water at the test temperature.
 H_t = effective depth at which the density of the suspension is measured (mm).
 ρ_s = particle size density (mg/m^3)
 t = elapsed time (minute)
 0.5531 = Constant

Statistics

Ecological Indices

Ecological indices for macroinvertebrates were employed to calculate the relative abundance of species by individuals in a community. The diversity indices - Margalef's index (Parsons, 1977), Shannon-Wiener (Ogbeibu, 2005), Equitability (Lloyd and Ghelardi, 1964), Menhinick's and Simpson's Dominance indices were calculated. Hierarchical clustering, non-Multidimensional Distribution (nMDS) was performed using data for environmental parameters and benthic abundance to visualize and assess the similarity among sampling stations (Legendre and Legendre 2012; Clarke and Gorley, 2015).

Results

Diversity Indices of Macrobenthic Invertebrates in Lagos lagoon

The spatial variations in the diversity indices {Margalef's (d), Sahnnon-Wiener (H_s), Equitability (j), Menhinick's (D) and Simpson dominance (C),} based on the bi-monthly collection of macrobenthic invertebrates at different stations of Lagos lagoon are presented respectively (Figure 2).

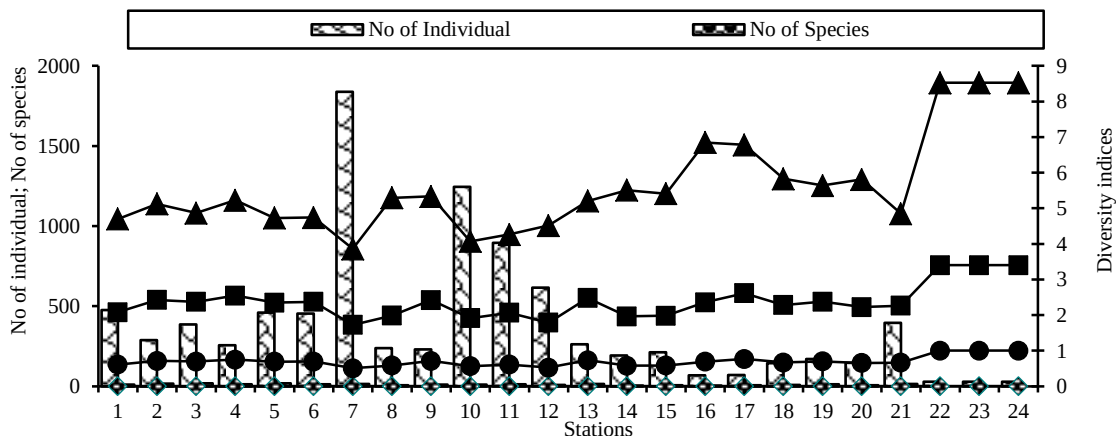


Figure 2: Spatial variations in the overall diversity indices of macrobenthic invertebrates at the study stations in western Lagos lagoon during the period of study.

Particle size characteristics of Sediment and Macrobenthic Invertebrates

Ordination analysis of the relationship between sediment particle size and macro-invertebrates community structure using non-metric dimensional scaling (nMDS) plot revealed that the majority of the macrobenthic invertebrate species are strongly closely related with the particle sizes of sediment except of a few species (Figure 3).

Benthic Community Structure comparison with Previous Studies of Western Lagos Lagoon

Evaluated particle size and depth in comparison with the previous study of Oyenekan (1975) were mapped and are as shown in Figures 4 - 5 respectively. The result showed that the present characteristics of these variables have changed spatially.

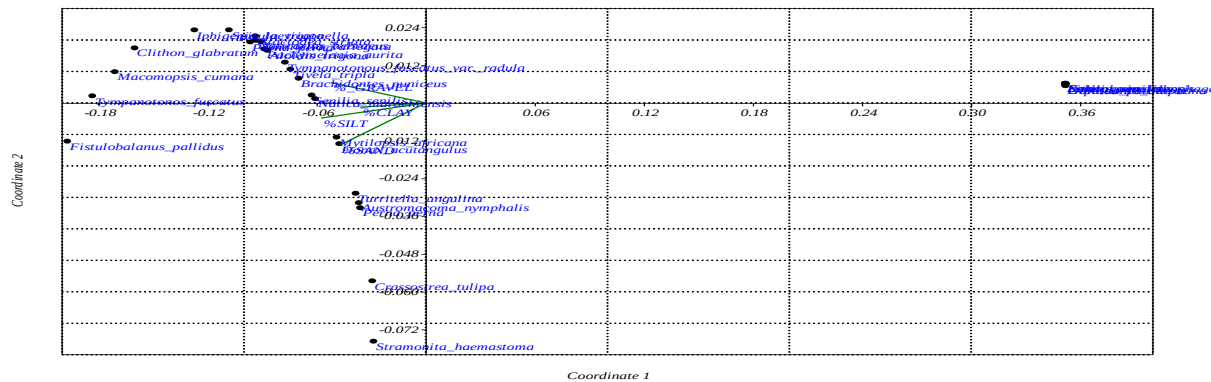


Figure 3: Non-metric multidimensional scaling (nMDS) of sediment particle size and macrobenthic invertebrates of western Lagos lagoon during the period of study.

Shift in sediment particle size characteristics from mud to sand is attributed to increased human- related activities in the study area.

The macrobenthic invertebrates and relative abundances of macrobenthic organisms recorded by Oyenekan (1988) and this present study is presented in Table 2.

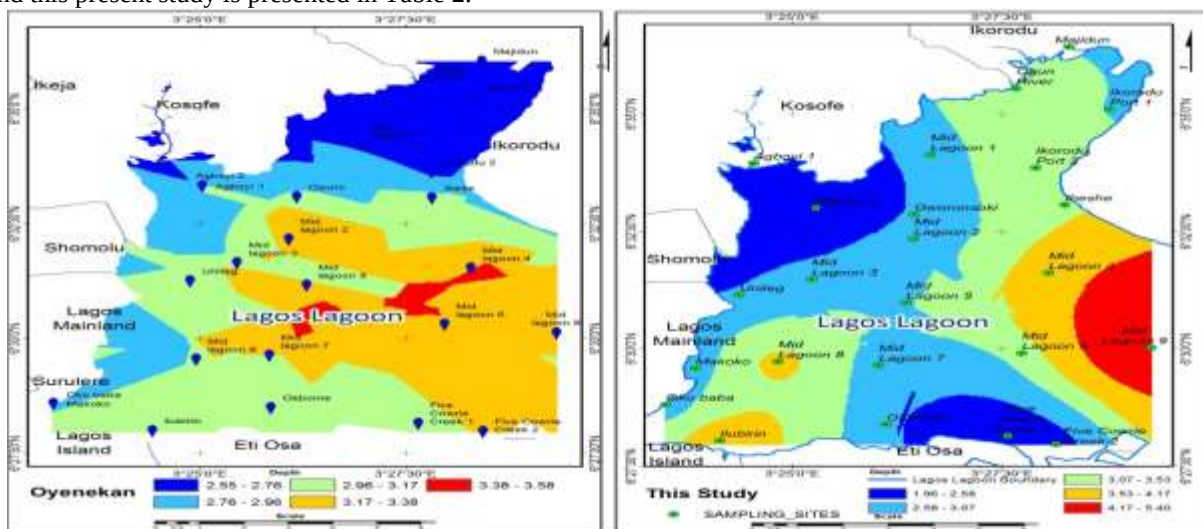


Figure 4a and b: The depth (m) in western Lagos lagoon Oyenekan 1975(a) study and Present study (b) in western Lagos lagoon.

Discussion

The overall pattern of macrobenthic species was very unstable throughout sampling among stations because responses of biological communities to environmental variables showed significant values which are possibly linked to anthropogenic influences. Amongst the class gastropoda, *Tympanotonus fuscatus* var. *radula* was the most abundant in the mud sediment type and the species presence was recorded at almost all the stations throughout the study period which is contrary to the reports of Ajao (1990) and Nkwoji, (2014). The *Tympanotonus fuscatus*, *Pachymelania aurita* and *Tympanotonus*

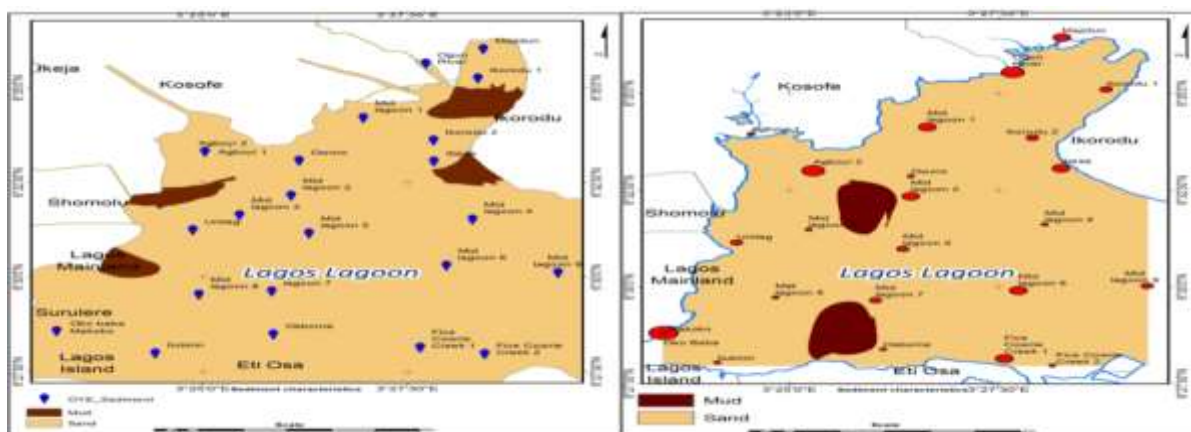


Figure 5a& b: The sediment type distribution (%) in western Lagos lagoon Oyenekan 1975 (a) study and Present study (b) in western Lagos lagoon.

fuscatus var. *radula* is a known species adapted to life survival outside water in extreme environmental conditions as reported by (Egonmwan 1980, Ajao, 1990). The species recorded in this study are common to the traditional ones obtained in other lagoons as reported by Lamptey and Armah (2008) in Keta Lagoon (Ghana) and Kouadio (2011) in Agneby lagoon (Côte d'Ivoire). However, their richness in the Lagos lagoon appears to be less compared to these lagoons despite its large surface area. The bivalve abundance was dominated by sandy sediment characterized *Iphigenia truncata* (Gmelin, 1791) species while the lowest abundance belonged to *Seniliassenilis* (Linnaeus, 1758) and *Spisulatrigonella* (Lamarck, 1818) respectively which is suggestive of the presence of more tolerant species- *Iphigenia truncata* (Martens, 1877), *Pachymelaniaaurita* (O. F. Müller, 1774), *Tympanotonusfuscatus* (Linnaeus, 1758), *Turritellavariegata* (Linnaeus, 1758) to mention a few.

The only recorded species of the crustacean class *Fistulobalanus pallidus* decreased in the abundance than previous works which are attributed to the change in the sediment characteristics at stations where the species were recorded.

The polychaetes were not recorded in this study despite the preference for polluted sites of organic matter and trace metals (Ajao, 1990) and are ranked as opportunistic species reported to inhabit areas of disturbance following a period of oxygen depletion. Their absence in this study may largely be due to the sandy characterised areas because the polychaete worms are largely reported to be situated in mud substrates.

The changes observed in the sediment chemistry of the study area possibly have had an enormous change to the community structure despite the presence of the five communities of macrobenthic invertebrates recorded by Oyenekan 1975, there are various changes in the composition characteristics. The venus community had only five representatives recorded namely *Turritella meta*, *Atactodeastriata*, *Naticamarochiensis*, *Macomopsiscumana* and *Tivelatripla*. These species were also mostly found present in the mud characterised stations. The mangrove community had four representatives namely *Tympanotonusfuscatus*, *Tympanotonusfuscatus* var. *radula*, *Pachymelaniaaurita* and *Brachyodontespuniceus*. The pachymelania community had *Alloidistrigona*, *Clithonglabratum* and *Austromacomanympalis*. These species are known to be euryhaline and in most of the sandy sediment types. The estuarine rock community of the dominant macrobenthic invertebrates had *Crassostreatulipa*, *Mytilopsisafricana* and *Neritasenegalensis*. The only recorded species of the estuarine - amphipoplus community

Table 2: Macrobenthic Invertebrates Relative Abundance between Oyenekan (1988) and This Study

OBSERVED SPECIES	CODE	OYENEKANs STUDY	PRESENT STUDY
<i>Tympanotonus fuscatus</i> (Linnaeus, 1758)	TF	22	502
<i>Tympanotonus fuscatus</i> var. <i>radula</i>	TFVR	25	599
<i>Pachymelania aurita</i> (O. F. Müller, 1774)	PA	98	518
<i>Turritella unguis</i> (Linnaeus, 1758)	TU	*	51
<i>Atactodeastriata</i> (Gmelin, 1791)	MG	*	1539
<i>Clithon glabratum</i> (Sowerby II, 1849)	NG	60	130
<i>Fistulobalanus pallidus</i> (Darwin, 1854)	FP	+++ (very abundant)	617
<i>Naticarius hebraeus</i> (Martyn, 1786)	NF	*	42
<i>Macomopsis cumana</i> (O.G. Costa, 1830)	MC	*	651
<i>Aloidistrigona</i>	AT	114	1363
<i>Iphigenia truncata</i> (Martens, 1877)	IT	38	1444
<i>Pernaperna</i> (Linnaeus, 1758)	MP	*	72
<i>Brachydontes puniceus</i> (Gmelin, 1791)	BP	2	17
<i>Mytilopsis africana</i> (Van Beneden, 1835)	MA	6	98
<i>Stramonitahastoma</i> (Linnaeus, 1767)	TH	17	3
<i>Crassostrea tulipa</i> (Lamarck, 1819)	CG	2	84
<i>Austromacoma nymphalis</i> (Lamarck, 1818)	TN	3	97
<i>Spisulatrigenella</i> (Lamarck, 1818)	ST	*	1
<i>Tivellatris</i> (Linnaeus, 1771)	TT	2	565
<i>Turritella variegata</i> (Linnaeus, 1758)	TM	1	111
<i>Naticamarochensis</i> (Gmelin, 1791)	NM	2	25
<i>Seniliasenilis</i> (Linnaeus, 1758)	SS	*	1
<i>Pernaperna</i> (Linnaeus, 1758)	PP	*	22
<i>Donax acutangulus</i> (Deshayes in Reeve, 1854)	DA	9	3
<i>Lithophagalithophaga</i> (Linnaeus, 1758)	LL	*	22
<i>Galatea paradoxa</i> (Born, 1780)	GP	*	6
<i>Anadara senilis</i> (Linnaeus, 1758)	AS	*	2
<i>Neritaserenensis</i> (Gmelin, 1791)	NS	++ (abundant)	62
<i>Diplodontiaphana</i> (Gmelin, 1791)	DD	1	34
<i>Solenogaster</i> (Cosel, 1993)	SG	*	7

species of the estuarine - amphipod community *Donax acutangulus* was recorded once in the entire study period with fewer species present in contrast to the report of Oyenekan (1988). Macrobenthic invertebrate species recorded previously by Oyenekan (1988) but encountered in this study are *Turritella unguis*, *Naticarius hebraeus*, *Macomopsis cumana*, *Pernaperna*, *Spisulatrigenella*, *Seniliasenilis*, *Lithophagalithophaga*, *Galatea paradoxa*, *Anadara senilis*, *Solenogaster* with a drastic increase in the *Atactodeastriata* and *Iphigenia truncata*. However, a noticeable reduction in the *Fistulobalanus pallidus* and *Neritaserenensis* species abundance was observed in this study. This significant observation may be related to the extreme change in the substrate characteristics while differences in the number of species abundance are largely due to anthropogenic influences.

Spatial variation in benthic invertebrate density

The methods of estimating macrobenthic invertebrates diversity used in this study with the theoretical assumption that diversity increases with time. The Margalef's index (d) is largely influenced by species richness and showed wide fluctuations in all the study stations. A decrease in the number of species is a useful measure of the severity of anthropogenic impacts while the decrease in diversity is an indicator of extreme environmental degradation. The increased abundance of species having low species richness appeared to be controlled by *Iphigenia truncata* because

the dominant molluscan macrobenthic invertebrates have replaced short-lived species in response to environmental disturbances.

Conclusion

Macrobenthic invertebrates as presented in this work is real progress towards reconciling past data between physical, and biological variables of Lagos lagoon to create an ecologically relevant outline of their relationships. The economic relevance of the Lagos lagoon makes it important to ensure its resources are used sustainably and regularly monitored to establish its true state.

References

- Ajao, E.A. (1990). The Influence of Domestic and Industrial Effluents on Population of Sessile and Benthic Organisms in Lagos Lagoon. . Ph.D. Thesis, University of Ibadan, Nigeria. 412pp.
- Allesina, S. and Paschal, M. (2008) 'Network structure, predator - Prey modules, and stability in large food webs', *Theoretical Ecology*, **1** (1), 55 –64.
- British Standards Institute (2016). *Methods of Test for Soils for Civil Engineering Purposes. General Requirements and Sample Preparation*. British Standards Institute Publication. 38pp.
- Clarke, K.R. and Gorley, R.N. (2015). Change in Marine Communities: An Approach to Statistical Analysis and interpretation. Plymouth Marine laboratory, Plymouth UK.
- Coll, M., Libralato, S., Tudela, S., Palomera, I. and Pranovi, F. (2008) Ecosystem Overfishing in the Ocean. *PLoS ONE* 3(12): e3881.<https://doi.org/10.1371/journal.pone.0003881>
- Diaz, R.J and [Rosenberg](#), R. (2008) Spreading Dead Zones and Consequences for Marine Ecosystems. *Science* **321** (5891):926- 929.
- Dunne A. J., William J. R. and Martinez D. N. (2002). Network Structure and Biodiversity Loss in Food Webs: Robustness Increase with Connectance. *Ecology Letters*, **5** (4): 558 – 567pp.
- Edmunds, J. (1978). *Sea shells and other molluscs found on West African coast and estuaries*, Ghana University Press, Accra. 146pp.
- Edokpayi, C. A. (2017). The beautiful creatures of the aquatic sediment: the benthos, a divine gift to mankind. Inaugural lecture series, University of Lagos Press. 78pp.
- Egonmwan, R.I. (1980). The Biology of *Tympanotonus fuscatus* var. *radula* (Gastropod: Prosobranchia, Potamidae). M. Sc. Thesis, University of Lagos, 45pp.
- Elliott, J. E. and Elliott, K. H. (2013) 'Tracking marine pollution', *Science*, **340** (6132): 556–558.
- Floehr, T., Xiao, H., Scholz-Starke, B., Li, W., Hou, J., Yin, D., Zhang, X., Ji, R., Yuan, X., Ross-Nickoll, M., Schäffer, A. and Hollert, H. (2013). Solution by dilution?—A review on the pollution status of the Yangtze River. *Environmental Science Pollution Research* doi: [10.1007/s11356-013-1666-1](https://doi.org/10.1007/s11356-013-1666-1)
- Kouadio, Z. A. (2011). *Dynamics of land use and hydrological behavior. Case of the coastal watersheds of Agnèby and Boubo*, Ph.D. thesis of the University of Abobo-Adjamé, Ivory Coast, 188pp.
- Lamprey, E. and Armah, A.K. (2008). Factors affecting macrobenthic fauna in a tropical hypersaline coastal lagoon in Ghana, West Africa. *Estuaries and Coasts* **31**: 1006 – 1019.
- Legendre, P., and Legendre, L. (2012). *Numerical ecology*, 3rd English Edition, Amsterdam, the Netherlands. 969pp.
- Longhurst, A. R. (1959). Benthos densities off tropical West Africa. *ICES Journal of Marine Science*, **25**(1): 21-28.
- Lloyd, M. and Ghelardi, R. J. (1964). A table for calculating the equitability component of species diversity. *Journal of Animal Ecology* **33** (2): 217 - 225.
- Nkwoji, J.A. (2014) Hydrochemistry, community structure of benthic macroinvertebrates of Lagos lagoon, Nigeria and respiratory physiology of some nereid polychaetes. PhD Thesis, University of Lagos, Lagos, Nigeria. 307pp.
- Ogbeibu, A. E. (2005). *Biostatistics: A Practical approach to Research and Data Handling*. Mindex Publishing Company Ltd. Benin City, Nigeria. 264pp.
- Oyenekan, J.A. (1975). A Survey of the Lagos lagoon Benthos (with particular reference to the mollusca). M.Sc. Dissertation, University of Lagos. 137pp.
- Oyenekan, J. A. (1988). Benthic macrofauna of Lagos lagoon, Nigeria. *Nigeria Journal of Science*. **20**: 45-51.
- Parsons, J. J. (1977). Geography as exploration and discovery. *Annals of the Association of American Geographers*, **67** (1): 1-16.

- Scholz-Starke, B. B., Li, H., Andreas, N., Stefan, F., Tilman, H., Henner, R.N., Martina, S. and Andreas, O. Richard (2018) 'Simulation-based assessment of the impact of fertiliser and herbicide application on freshwater ecosystems at the Three Gorges Reservoir in China', *Science of the Total Environment*, **639**: 286–303.
- Tappin, A. D. and Millward, G. E. (2015) 'The English Channel: Contamination status of its transitional and coastal waters', *Marine Pollution Bulletin*. **95** (2): 529–550.
- United States Environmental Protection Agency (2001). *Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses*: Technical Manual. EPA 823-B-01-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC. 208pp.
- Washington State Department of Ecology (2008). *Guidance on the Development of Sediment and Analysis Plans Meeting the Requirements of the Sediment Management Standards (Chapter 173 – 204 WAC)*. Ecology Publication 152pp.
- World Register of Marine Species (2017). <http://www.marinespecies.org>. Last visited on 30th May 2019.

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Survey of Cichlid Fishes of Otamiri River, Imo State: The Eco-Morphological Adaptation to Aquatic Life

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Abstract

The body morphometric, the feeding ecology and environmental factors controlling the distribution of the Cichlid fishes in Otamiri River, Imo State in relation to the growth biology and adaptation of the fish to aquatic life were studied between February and March 2021. One hundred and six (106) samples were collected and identified. The fish identified were *Tilapia zilli*, *Tilapia mariae*, *Oreochromis niloticus*, *Tilapia guineensis*, *Sarotherodon melanotheron*, *Pelmatichromis taeniatus*, *Tilapia aurea*, *Tilapia melaontheron*, *Sarotherodon galibeeas*, *Tilapia digati*, *Hemicronus fasciatus*, *Hemicronus elongates*. The standard length fell was between 13.70cm and 17.40cm and body weight between 160.80g and 166.71g. The fishes fed mainly on detritus and plant materials. Detritus constituted about 90%, Spirogyra 38%, Diatoms 68%, higher plant materials about 80% and unidentified 89%. The fishes are omnivorous feeders and with the availability of food and nutrient, the fishes display sustenance growth and abundant fishery production in the Otamiri River.

Keywords Cichliformes, Species, Mouth-brooding, Fry, Egg

Introduction

The Cichlids are of the family Cichlidae in the order Cichliformes. Fryer and Iles (1972) stated that the Cichlids are known to have evolved rapidly into many closely related but morphological diverse species. The Cichlids of *Tilapia* species are important food stock. They have great parental care for their eggs and fry in form of guarding them, by mouth-brooding. As a group, Cichlids exhibit a striking diversity of body shape, strongly laterally compressed species such *Tylochronuissudanensis* species and cylindrical and highly elongated body such as *Pelmatichromistaeniatus* (Olasebikan and Raji, 1998).

Cichlids have evolved different types of feeding habits and are generally omnivorous feeders (Onimisi and Ogbe, 2015a). Cichlids exhibit a unique pattern of oval-shaped, colour dots on their anal fins. Froese et. al. (2006) explains some important characteristics that distinguish the Cichlids within the family, including a single nostril on each side of the fish head, division of the lateral line into two. Onimisi (2018) explains that morphometric measurements are a major biological tool for identifying fish populations. Also, morphological characteristics such as body length and weight and structure of feeding apparatus have been used to determine the growth rate and abundance of fish and relate same to feeding habit (Karachle and Stergion; 2010a). Knowledge of the food and feeding habit of fish species is useful for a proper understanding of the fishery. Onimisi (2018) quoting Oronsaye and Nakpodia, (2005); Guputa and Banerjee, (2004); Rama Rao, (2017) explains that studies on the feeding ecology of fish in a habitat are useful to determine the population level of the species since the number of individuals of a fish population depends on the amount of food available for the development of a successful fisheries management programme both in the wild, under culture and in captivity. Many research works have been carried out on the morphometric and feeding ecology in relation to adaptation to aquatic life of fishes. For example, Omoniyiet. al. (2011) reported on the morphometric variation and food habits of *Ctenopoma petherici* Gunther in River Oluwa, Ondo State, Nigeria, Lawa et. al. (2010). Worked on the morphometry and diet of *Chrysichthys nigrodigitatus* in Epe Lagoon; Onimisi and Ogbe (2015a) gave a morphometric account of three Cichlids *Tilapia zillii*, *Oreochromis niloticus* and *Chromidotilapia guntheri* from River Okura.

Cichlids exhibit a unique pattern of oval-shaped, colour dots on their anal fins. Olasebikan and Raji, (2004) showed that these features are for sexual attractions and further explained some important characteristics that distinguish the Cichlids within the family, including a single nostril on each side of the fish head, division of the lateral line into two. Onimisi (2018) explains that morphometric measurements are major biological tool for identifying fish populations. Also morphological characteristics such as body length and weight and structure of feeding apparatus have been used to determine growth rate and abundance of fish and relate same to feeding habits (Karachle and

Stergion; 2010b). Knowledge of morphometric adaptation and food and feeding habit of fish species is useful for proper understanding of the fishery. Onimisi (2018) quoting Oronsaye and Nakpodia(2005):Gupta and Banerjee(2014) explain that studies on the feeding ecology of fish in a habitat are useful to determine the population level of the species since the number of individuals of a fish population dependson the amount of food available to the population.

The Cichlids are a common fish in the fisheries catch of Nigerian waters as found out by Nwadiaro and Okereke (1993); Ohaturonyeet. al. (2018).Correlatingthe food and feeding habit of the Cichlids to their morphology and ecology to aquatic adaptation would be a successful agenda for their fisheries with adequate understanding of the morphology and feeding habits. This present research is therefore aimed at studying the ecomorphological adaptations of the Cichlid fishes in relation to their feeding habits to aquatic life and elucidating the salient factors that support their success in Otamiri River.

Materials and Methods

Study Area

The study area is the Otamiri River behind the Fisheries and Marine Technology Department, Imo State Polytechnic.

Description of Study Area

Otamiri River originated at Egbu, in Owerri North LGA and conflues with Nworie Stream in Owerri Municipal area. The River lies between the longitude 06°57' to 0.11°46' E and latitude 05°20' to 0.35°, 66°N' spanning 2 kilometers (Urban and Regional planning, Imo State Polytechnic, Umuagwo) as described by Nwadiora and Okereke, 1993). The entire area lies 61-122m above sea level. The river starts as a first- order stream, then flows westward for about 7km to receive another first -order stream Nworie. From that point, it flows southwards as a second- order river for 28 kilometers and receives a major tributary, River Oramiruka. At the Oramiruka input, it continues southward for another 21km before it reaches Ogochia River, its third tributary in Etche LGA in Rivers State. It finally continues for another 26km downstream to the south near Owaza in Ikwerre LGA of Rivers State, where it discharges into Imo River. The length from source to mouth is approximately 82 kilometers.

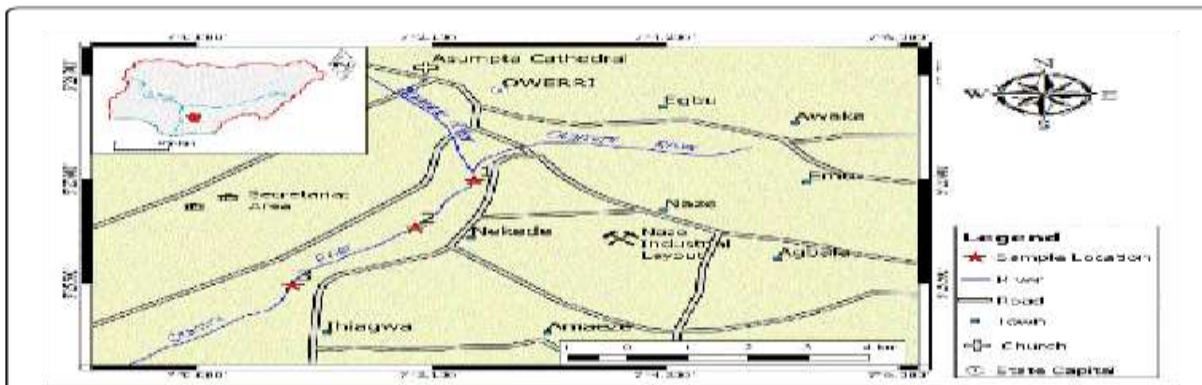


Fig 1: Map of the Study Area

Fish Sampling

- Fishes were caught by Departmental fisherman
- This project was carried out for 4 weeks, fishing twice a week
- The fish of the Cichlidae family were identified, Olasebikan and Raji(1998).
- Data on fish species were collected weekly using hook and line and conical net.
- All laboratory protocols were observed e.g morphometric measurement such as Standard length(ST), Total length(TL),and Weight(WT).
- Dissection was done to expose the gut and the stomach, and identify the food materials.
- Stomach content analysis was done using the frequency of occurrence and numerical methods.
- Determine all parameters to justify the success of the class Cichlidae in Otamiri River.

Results

Morphometric Data

Tables 1 -7 show the number of Cichlid fishes sampling during the four week sampling period. In week 1 the total number of fish sampled was 29 fishes (Tables 1 & 2), week 2, 23 fishes (Tables 3 & 4), week 4, 25 fishes (Table 5) and week 5, 25fishs (Tables 6 &&).The mean weight of fish caught was 140.81g. The mean TL was indicated 1.1796cm, ST 100.96cm.

Stomach content Analysis

Detritus and unidentified food items constituted 89% of the food materials found in the stomach of the fishes, leaves of higher plants were 80%. Table 8 shows the analysis of stomach contents.

Discussion

With the highly complex social behaviour and diverse morphology, Cichlid fishes exhibit a striking variation in body colouration. Previous works (Fryer and Iles, 1972) have identified numerous selective forces involve in the origin with of a divergence of Cichlid colouration.All Cichlids have some form of parental care for their eggs and fry. The parental cares come in form of guarding the eggs and fry or it may come in form of mouth-brooding. Cichlids span a wide range of body sizes from species as small as 2.5cm (0.98g). The body shape and average size length help them in aquatic adaptation. A single nostril on each of the forehead instead of two, no bony shelf below the orbit of the eye; division of the lateral line organ into two sections, on the upper half of flank and a second along the midline of the flanks from about halfway along the body to the base of the tail. All these body characteristics have for dexterity for water.Onimisi (2018) submitted that all fishes vary tremendously in morphology and physiology of digestive trackand in feeding behaviour, and noted that some fish have gut lengths less than one-half of their body length, especially carnivores fishes and others have got about six to eight times of their body length (Falayi, 2009 and Kalachle and Stergiou, 2010a). For example,Falayi (2009) observed that *Heterobranchuslongifilis*in river Okura was an Omnivore materials like fish remains and insects. In this research the Cichlid fishes eat mostly plants and plant remains which made them to be omnivores, in comparism to *H. longifilis*, which tended towards carnivore. The gut length ranged between 0.6 to 1.3 as the standard length of the fish is patterned after its carnivores habit. The diet of *H. longifilis*included animal remains. All Cichlids have some form of parental care for their eggs and frys. The parental care come in form of guarding the eggs and fry in mouth-brooding.The omnivorous nature of the cichlid fish endows it to many niches known in fresh water ecosystem. The structure of the body with well defined lateral line endows the fish for active life in water. This is very important as it enables the fish for great abundance and biodiversity, Falayi(2009).the observation seen in this present research conforms with the results of latest research such as, Falayi(2009),Onimisi (2018).

Conclusion and Recommendations

The study reveals the great importance of the Cichlid fishes in theOtamiri River. The success of this class of fish in the River is evidenced by: Their morphometric adaptation with well-defined stream-linebody with coordinating digestive track that adulate to eat available food items and with the omnivorous gut system that support their feeding habit. The types of food and their reproduction potentials.The Cichlids are known to have great parental care, even as far as mouth-brooding. This ensure high protection of the young ones and thus ensures great abundances of the fish in the water. In addition, they are known to lay a large number of eggs that are which are jealously protected till they are hatched, ensuring great protection of their young ones. The fishers in Otamiririver decry the obnoxious activities of sand dredgers in the rivers whose activities destroy the river ecosystem and make fishing unsustainable agricultural business in the river.All efforts by all stake-holdersincluding fishery professionaland all relevant government agencies are requested to put in place strict measures that will checkmate the activities of the sand dredgers. The stake-holders are required to formulate laws that will check-mate the activities of the sand dredgers. Also breeding eco system areas may be mapped out as breeding ground and preserved for such purposes in Otamiri river to ensure uninterrupted breeding cycle.

References

Table 1: Shows the sampled data as carried out on 03-02-2021

S/N	WT(g)	TL(cm)	ST(cm)
1	168.54	18	15
2	192.65	19	16
3	151.65	15	12
4	165.16	17	14
5	150.16	15	13
6	149.15	14	12
7	150.190	15	13
8	168.54	18	16
9	150.17	15	13
10	162.10	16	13
11	160.80	16.20	13.7

Table 2: Shows the sampled data as carried out on 08-02-2021

S/N	WT(g)	TL(cm)	ST(cm)
1	165.51	17	15
2	150.12	15	12
3	198.20	20	18
4	169.56	18	15
5	151.18	15	12
6	130.40	12	11
7	150.15	14	12
8	162.10	16	13
9	168.54	18	12
10	150.17	15	13
11	165.50	17	14
12	165.17	17	15
13	150.15	14	12
14	168.54	18	16
15	154.20	15	12
16	162.10	16	13
17	168.53	18	14
18	165.50	17	15
19	154.20	15	12
20	76.52	16.15	16.52

Table 3: Shows the sampled data as carried out on 11-02-2021

S/N	WT(g)	TL(cm)	ST(cm)
1	168.54	18	15
2	151.17	15	12
3	150.18	15	13
4	149.15	14	12
5	150.20	15	12
6	193.60	19	16
7	165.50	17	13
8	168.54	18	15
9	162.10	16	14
10	150.17	15	12
11	160.61	16.20	13.4

Table 4: Shows the sampled data as carried out on 15-02-2021

S/N	WT(g)	TL(cm)	ST(cm)
1	160.17	15	13
2	165.51	17	13
3	150.16	14	12
4	167.55	18	12
5	150.17	15	15
6	150.17	15	13
7	162.10	16	12
8	168.54	18	12
9	170.15	19	15
10	152.15	15	12
11	169.57	18	16
12	165.50	17	13
13	171.15	19	15
14	161.76	16.11	13.61

Table 5: Shows the sampled data as carried out on 18-02-2021

S/N	WT(g)	TL(cm)	ST(cm)
1	100.12	15	13
2	162.10	16	14
3	165.50	17	14
4	150.15	14	12
5	168.54	18	14
6	168.12	18	12
7	154.20	15	12
8	165.17	17	14
9	193.60	19	16
10	162.10	16	13
11	199.20	20	15
12	169.40	18	13
13	165.17	15	12
14	193.55	19	16
15	149.60	14	12
16	165.50	17	14
17	193.60	19	16
18	162.10	16	13
19	150.18	15	13
20	162.10	16	13
21	168.54	18	14
22	149.15	14	12
23	166.71	18.22	12.95

Table 6: Shows the sampled data as carried out on 22-02-2021

S/N	WT(g)	TL(cm)	ST(cm)
1	199.20	20	18
2	150.12	15	12
3	165.14	17	15
4	160.20	15	12
5	166.12	17	14
6	150.12	15	13
7	170.13	19	16
8	167.14	18	15
9	151.15	14	12
10	150.15	14	12
11	168.12	18	15
12	163.60	16.63	14

Table 7: Shows the sampled data as carried out on 25-02-2021

S/N	WT(g)	TL(cm)	ST(cm)
1	150.15	14	10
2	165.50	17	13
3	168.48	18	15
4	154.30	15	12
5	165.30	17	12
6	150.15	14	11
7	162.10	16	12
8	154.20	15	12
9	170.13	19	15
10	165.50	17	13
11	168.17	18	13
12	162.10	16	13
13	198.20	19	15
14	170.20	19	15
15	157.47	16.78	13.5

Table 8: Analysis of stomach content of Cichlid fishes sampled using numerical method and frequency of occurrence method.

FOOD ITEMS	Frequency of occurrence		Numerical method	
	No of fish stomachs	Percentage frequency	Number of food items	(%) number
Detritus	99	72	11	3.7
Higher plant Plants, Leaves kernel shafts	80	53	16	5.4
Unicellular algae	42	24	20	5.7
Chlorophyceae	27	18	65	22
Greenesdesmus	78	19	30	12
Flametous Green algae		18		
Spirogyra	38	29	52	18
Diatoms	68		65	20
Rotifer		30		3
Karallela	12	40	8	8
Unidentified	89		22	

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Effect of Crude Oil Spillage on Growth and Mortality Rate of African Catfish (*Clarias gariepinus*)

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Abstract

This study evaluated the effect of crude oil spillage on the growth and mortality rate of cultured African Catfish. A Completely randomized design was used for the experiment with one (1) treatment and four replications with a control. Fish samples were purchased from Mira and Obey Aqua-cultural Farm in Ogbidi community in Ogba Egbema Ndoni Local government Area of Rivers State. The experiment involved culturing of juveniles for two months. The initial weight and initial length of fish at the time of purchase were determined before stocking. Stocking was done using four (4) earthen ponds (4m x 4m (width) x 7ft (depth) x4) filled with supplied water. The four ponds were divided into two water bodies; unpolluted (control) and oil-polluted (treatment). Feeding was done twice daily for two months at 5% body weight. The length and weight of fish were determined using the weighing balance and meter rule. The mortality rate of fish was determined using percentages. Data analysis was done according to the growth performance indices evaluation. The results from the study revealed that the mean length of African Catfish in unpolluted water bodies was 5.25cm while the mean length of catfish in oil-polluted water bodies was 1.88cm; the mean weight of catfish in the unpolluted water body is 12.49g while the mean weight of catfish in crude oil populated water body is 5.25g respectively. There was a high percentage (65%) of mortality on catfish cultured in crude oil polluted water bodies. Crude oil spillage has a significant $P < 0.05$ effect on the growth and mortality rate of African Catfish. This study affirmed the cries from the oil-producing communities that crude oil spillage has significantly affected their livelihood and hence government were to thoroughly clean up the environment of the oil-producing communities and adequate monetary compensation be paid to the people for the monumental impact they suffered from oil exploration and exploitation.

Keywords: Oil Spillage, Growth, Mortality rate, *Clarias gariepinus*

Introduction

Fish is currently the cheapest source of animal protein consumed by the average Nigerian and it accounted for about 50% of total protein intake (Ayinla, 2007). Fish supply in Nigeria is mainly from the capture sector, especially the coastal and inland artisanal fisheries. The sector contributes about 85% of total domestic production (FAO, 2015). Nigeria imports over 700,000 metric tonnes of fish per annum, and an annual deficit of about 0.5 million metric tonnes still exist. Aquaculture in Nigeria is receiving wide participation as a result of the progressive development in most parts of the country. The total current aquaculture production has leapt from 50,000 metric tonnes in 2005 to 85,000 metric tonnes (Akinrotimi, *et al*, 2011), and demand is expected to continue to grow with anticipated population growth. As of 2004, there are over 2,600 fish farms and 215 feeds mills in the country with most of them located in the southern part of Nigeria, and fish feeds account for about 60% of the input cost production in an intensive system in Nigeria (Ayinla, 2007). Aquaculture activities are concentrated in the coastal areas and have been faced with several constraints amongst which are the industrial activities like oil exploitation which has led to problems of oil spillage.

The Oil producing area of Nigeria is known as the Niger Delta, which is located in the Atlantic Coast of southern Nigeria where the River Niger divides into numerous tributaries. It is the second-largest delta in the world with a coastline spanning about 450 kilometres terminating at the Imo River entrance (Awosika, 1995). The region spans over 20,000 square kilometres and it has been described as the largest wetland in Africa and among the three largest in the world. About 2,370 square kilometres of the Niger Delta area consist of rivers, creeks and estuaries and while stagnant swamp covers about 8,600 square kilometres. Oil-producing area ecosystem is highly diverse and supportive of numerous species of terrestrial and aquatic flora and fauna and human life. As opined by (Iyayi, 2004), it is the richest wetland in the world. Oil was first discovered in the region in 1958 and since the early 1970s, oil has

dominated the country's economy. Oil exploration has over the years impacted negatively on the physical environment of the oil-bearing communities.

Crude Oil spillage is massively threatening the subsistence peasant agricultural economy and environment; hence the entire livelihood and survival of the people (Ekpenyong and Udofia, 2015). Oil spillage is the release of petroleum substance or product into the streams, lakes, rivers, beaches, seas, oceans and land. When this occurs, it becomes poisonous and thus makes the water and land fouled and threatened by the rich coastal habitat. Oil poisons algae disrupt major food chains and decrease the yield of edible crustaceans. Both actual and potential contamination of seafood can substantially affect commercial and recreational fishing and the attendant loss of confidence in seafood safety and quality can impact the seafood market long after any actual risk to seafood from oil spill has subsided, resulting in serious economic consequences (Ekpenyong & Udofia, 2015). The exploitation of oil in the Niger Delta region has brought to bear oil spillage and its numerous problems. Such problems include contamination of water bodies, danger to aquatic life, and destruction of farmlands, (Nwilo & Badejo, 2008).

Materials and Methods

Study Area

The study was carried out in Bane town, Khana Local Government Area of Rivers State. Khana Local Government area is one of the four LGA within the Ogoni tribe in Rivers State. It is one of the oil-producing regions in Rivers State. Bane town lies between longitude 7° 30' 22" E and latitude 4° 38' 57" N.

Fish Samples

Fish samples were purchased from Mira and Obey Aqua-cultural Farm in Ogbidi community in Ogba Egbema Ndoni Local government Area of Rivers State. Ogbidi community lies between longitude 6° 39' 8" E and latitude 5° 17' 39" N. The experiment involved culturing of juveniles for two months. The initial weight and initial length of fish at the time of purchase were determined before stocking. Stocking was done using four (4) earthen ponds (4m x 4m (width) x 7ft (depth) x4) filled with supplied water. The four ponds were divided into two water bodies; unpolluted (control) and oil-polluted (treatment). Feeding was done twice daily for two months at 5% body weight.

The length and weight of fish were determined using the weighing balance and meter rule. The mortality rate of fish was determined using percentages.

Data Analysis

Data analysis was done according to the growth performance indices evaluation method; this method involves the determination of weight gained and length gained by the fish at the end of the experiment.

Growth performance parameters:

Mean Weight Gain (g) (MWG)

$MWG = Wt2 - Wt1$

Where

Wt1 = initial mean weight of fish

Wt2 = final mean weight of fish

Mean Length gain (cm) (MLG)

$MLG = FL2 - FL1$

Where

FL1 = initial mean length of fish

FL2 = final mean length of fish

Source: (Eyo and Ekanem, 2011).

The mortality rate was determined using percentage calculation; while the hypothesis was tested using a t-test at 0.05 significant levels.

Results

Fish samples

A total of 40 juveniles of African Catfish (*Clarias gariepinus*) were used for the experiment.

Table 1a: Mean Length of African Catfish Cultured in Oil Polluted and Unpolluted Water Bodies.

Growth Parameters		Samples				Total	Mean	MLG
Unpolluted (control)								
Initial Length (Lt1)		6	6	6	6	24cm	6cm	
Final Length (Lt2)		10.5	11	11.5	12	45cm	11.25cm	
MLG = Lt2 – Lt1								5.25cm
Polluted (Treatment)								
Initial Length (Lt1)		6	6	6	6	24cm	6cm	
Final Length (Lt2)		7	9	8	7.5	31.5cm	7.88cm	
MLG (Lt2 – Lt1)								1.88cm

All measurements are in centimeters (cm)

Table 1a: Indicates the growth length of African catfish cultured in crude oil-polluted and unpolluted water bodies. The table showed initial mean length $\bar{x}$ =6cm for unpolluted and $\bar{x}$ = 6cm for oil polluted Final

Table 1b: T-test on the significant effect of oil spillage on the length of African Catfish Cultured in crude oil polluted water body.

Length Growth	$\bar{X}$	SD	N	Df	Standard error	t-cal	t-tab
Unpolluted	11.25	0.56	4	6	0.31	10.87	1.943
Polluted	7.88	0.73	4				

Comparing the t-Cal (10.87) and the t-tab (1.943), since the t-calculated is greater than the t-tabulated, the null hypothesis is therefore rejected, which states that oil spillage has no significant effect on the length of cultured catfish at $P \geq 0.05$. It is therefore, concluded that crude oil spillage has a significant effect on the growth (Length) of Cultured Catfish Cultured in Khana LGA of Rivers State.

Table 2a: Mean weight of African Catfish cultured in crude oil-polluted and unpolluted water bodies

Growth Parameters	Samples				Total	Mean	MWG
Unpolluted (control)							
Initial Weight (wt1)	0.004	0.004	0.004	0.004	0.016g	0.004g	
Final weight (wt2)	12.5	12.5	12	13	50g	12.5g	
MWG = (Lt2 – Lt1)							12.49g
Polluted (Treatment)							
Initial Weight (wt1)	0.004	0.004	0.004	0.004	0.016g	0.004g	
Final Weight (wt2)	5.5	5.5	5	5	21g	5.25g	
MWG = (wt2 – wt1)							5.25g

All measurements are taken in gram (g).

Table 2a indicates the growth (weight) performance of African catfish cultured in crude oil-polluted and unpolluted water bodies. The Table showed initial mean weight ($\bar{wt}_1$); $\bar{x}$ = 0.004g for unpolluted water body and $\bar{x}$ = 0.004g for oil- polluted water body. A final mean weight ($\bar{wt}_2$) of $\bar{x}$ = 12.5g was recorded for unpolluted water body while fish culture in oil- polluted water recorded a final mean weight ($\bar{wt}_2$) of $\bar{x}$ = 5.25g.

Comparing the mean weight gain (MWG) for unpolluted water body ($\bar{x}$ = 12.4g) and weight gain for oil- polluted water body ($\bar{x}$ = 5.25g). The study revealed that catfish cultured in unpolluted water bodies performed better in

growth (weight) with an MWG ($\bar{x}$ = 12.49g. This implies that crude oil spillage inhibits or affects the growth performance (weight) of cultured catfish in the study area.

Table 2b: T-test on significant effect of oil spillage on the weight of African Catfish cultured in Crude Oil Polluted Water Body.

Weight Growth	$\bar{X}$	SD	N	Df	Standard error	t-cal	t-tab
Unpolluted	12.5	0.35	4				
Polluted	5.25	0.25	6	0.14	61.76	1.943	

Comparing t-cal (51.79) and t-tab (1.943), since the t-calculated is greater than the t-tabulated, the null hypothesis is therefore, rejected, which states that oil spillage has no significant effect on the weight of cultured catfish at $P \geq 0.05$. It is therefore concluded that crude oil spillage has a significant effect on the growth (Weight) performance of catfish in Khana LGA of Rivers State.

Table 3: Mortality Rate of African catfish cultured in crude oil polluted water body.

Parameters	Total stock	Death rate	Survival rate	% mortality
Unpolluted	20	4	16	20%
Polluted	20	13	7	65%

Measurements were taken in percentage.

Table 3 indicates the percentage mortality of African catfish cultured in oil-polluted and unpolluted water bodies. The study recorded a death rate of 13 fish for the polluted water group while the unpolluted water group had a death rate of 4 fish out of the total stock (20 fish) per group. 65% mortality was recorded for oil-polluted water body while 20% was recorded for the unpolluted group.

The study showed that higher percentage mortality of 65% was recorded for fish stocked in crude oil polluted water bodies.

This implies that crude oil spillage has a negative effect on the survival of catfish. It is concluded that crude oil spillage has a significant effect on the mortality rate of cultured catfish in Khana LGA of Rivers state.

Discussion

Growth performances of catfish connote an increased level of the fish in terms of body length and weight. According to Eyo and Ekanem (2011) growth performance can be measured using growth performance parameters such as mean length gain (MLG) and mean weight gain (MWG). On the mean length of cultured catfish, a mean length gain (MLG) of = 5.25cm was recorded for catfish cultured under unpolluted water body while a mean length gain of = 1.8cm was recorded for catfish cultured in crude oil pollinate water. This implies that crude oil pollution inhibits the growth (length) of cultured fish. The study revealed that crude oil spillage had a significant effect on the length of cultured African catfish at $P \geq 0.05$. This finding is in line with Akpokodje and Salau (2015) who reported that increasing the level of oil spillage negatively affects agricultural productivity in the Niger Delta.

The study further revealed that African catfish cultured in unpolluted water bodies had a mean weight gain of =12.49g while a mean weight gain of 5.25g was recorded for cultured catfish in oil- polluted water bodies. This implies that the growth (weight) of cultured catfish is negatively affected by crude oil spillage. T-test results showed that oil spillage had a significant effect on the growth (weight) of African catfish cultured in crude oil polluted water bodies at $P \geq 0.05$. These findings agreed with Olaifa and Osuagwu (2011) who established in their study that oil spills and oil production negatively affect fish production in the Niger Delta region of Nigeria.

Assessing the death rate of fish cultured in an oil- polluted water body, the study showed that a large number (13) out of the total stocked fish (20) in polluted water bodies died. A percentage mortality rate of 65% was recorded. This implies that crude oil spillage had a significant effect on the mortality rate of cultured catfish at $P \geq 0.05$. This finding also agreed with Osuagwu and Olaifa (2018) who stated that oil spills and oil production negatively affect fish production in the Niger Delta region of Nigeria. Statistically, the study established that crude oil spillage negatively affects aquaculture production of catfish in Khana LGA, Rivers State, Nigeria.

Conclusion

Based on the findings from this study, the researcher concludes that crude oil spillage pollutes the natural water bodies available for aquacultural purposes. This growth performance and survival of cultured fishes, in turn, affect the profitability of the aquaculture business and these negatively affect the livelihood of the Niger Delta inhabitants.

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References

- Akinrotimi, O.A., Abu, O.M.G., & Aranyo, A.A. (2011). "Environmental Friendly Aquaculture Key to Sustainable Fish Farming Development in Nigeria." *Continental J. Fisheries and Aquatic Science* 5 (2): 17-31.
- Awosika, L.F. (1995). Impacts of Global Climate Change and Sea Level Rise on Coastal Resources and Energy Development in Nigeria In: Umlu J.C., (ed). *Global Climate Change: Impact on Energy Development*. DAMTECH Nigeria Limited, Nigeria.
- Ayinla, O.A. (2007). "Analysis of Feeds and Fertilizers for Sustainable Aquaculture Development in Nigeria." In *Study and Analysis of Feeds and Fertilizers for Sustainable Aquaculture Development*, edited by Hasan, M. R., Hecht, T., De Silva, S. S., and Tacon, A. G. J. Rome: FAO, 453-70.
- Akpokodje, J., & Salau S. (2015). Oil pollution and agricultural productivity in the Niger Delta of Nigeria. *Journal of Environmental Economics*, 6 (4), 68–75.
- Ekpenyong, N.S., & Udofia, U. S. (2015). Crude Oil Spills and its consequences on seafoods safety in coastal area of Ibeno: Akwa Ibom State. *Studies in Sociology of Science*, 6 (1), 1-6.
- Eyo and Ekanem. (2011). Effect of Feeding Frequency On The Growth, Food Utilization and Survival of African Catfish (*Claria gariepinis*) Using Locally Formulated Diet. *Afrocan Journal Of environmental Pollution And Health. Biology*
- Iyayi, F. (2004). An integrated approach to development in the Niger Delta. A paper prepared for the Centre for Democracy and Development (CDD)
- Nwilo, P.C. & Badejo, O. T. (2008). Oil Dispersion and Trajectories on Nigerian open sea. The Conference Proceedings of the International Conference on the Nigeria State, Oil Industry and the Niger Delta, 164–192.
- Osuagwu, E.S., & Olaifa, E. (2018) Effects of oil spills on fish production in the Niger Delta. PLoS ONE 13(10): e0205114. <https://doi.org/10.1371/journal.pone.0205114>.
- FAO (2015). "FishStatJ—Software for Fishery Statistical Time Series." FAO Fisheries and Aquaculture Department, Rome. Accessed June 23, 2015. <http://www.fao.org/fishery/statistics/software/fishstatj/en>.

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Diversity Metrics and Seasonal Indices of Fish Fauna, In South-West Estuary, Lagos, Nigeria

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Abstract

Diversity metrics are used in the study of ecology and biodiversity monitoring. A diversity index assesses environmental quality, thus healthy and bad conditions are indicated with high and low index values. This study assessed the fish abundance and its seasonal changes with different types of diversity indices, Shannon(H), Dominance(D), Evenness(E), Simpson(I-D) to reiterate the health status of Badagry creek within the period of July 2017 – May 2019. Fish samples (1533) were collected bi – monthly, during the wet and dry season. January 2019 had highest H, D and E value indices (2.31; 0.11; 0.91) and lowest value in September 2017 (1.12; 0.41; 0.77) respectively. The diversity indices of combined seasons were H: 2.91, D: 0.08, I-D: 0.92, and E: 0.52. A total no of 35 species belonging to 25 families was recorded during the period of study. *Chrysichthys nigrodigitatus* was a prominent specie recorded throughout the sampling period, T-test statistical analyses showed that there was significant difference in the abundance and occurrence of some species (*Chrysichthys nigrodigitatus*, *Cynoglossus senegalensis*, *Eucinostomus melanopterus*, *Ethmalosa fimbriata*, *Polydactylus quadrifilis*, *Sardinella madrensis*, *Pomadourus jubenini*) that were recorded during wet and dry seasons. The mean values of pH, salinity, and Dissolved Oxygen (7.44 ± 0.04 , 3.98 ± 0.48 , and 5.89 ± 0.11) were non-significantly different, while Alkalinity and Chloride (49.94 ± 1.52 , 670.81 ± 9.27) were significantly different. The Shannon(H) values recorded for 24 months were $1 > 3$, hence it is an indication that the Creek is moderately polluted throughout the period of the study.

Keywords: Fish, Seasonal, Metrics, Diversity

Introduction

The durability of many fish species makes them competent and temporarily integrated indicators of ecosystem status (Vander Zanden and Vadeboncoeur, 2002; Alexander et al., 2015). Species richness is controlled by distribution and occupancy-saturation of the number of niches available, limiting the number of species that can co-exist locally (Beaugrand et al., 2018). Spatial scales selection and understanding of local biodiversity capacity are both used for assessment and analysis of observed patterns especially recognition of anthropogenic effects (Murillo et al., 2020). This study assessed the relative abundance, richness and diversity of fish fauna using diversity index.

Materials and Methods

Study Area

The fish samples were collected from nine sampling stations in Badagry creek, Nigeria.

Collection of specimens and field studies

The fish specimens used for this study were caught with cast nets with varied mesh sizes (37, 67, and 76 mm) in the Badagry Creek bi-monthly, during wet and dry seasons from July 2017 to May 2019. The specimens were preserved in an ice-chest containing ice cubes in the field and later transferred into a deep freezer (temperature -20°C) in the laboratory after sorting and identification prior to further examination. Appropriate texts used in fish identification include Carpenter and De Angelis (2016) and Olaosebikan and Raji (2013). During each trip, surface water, bottom water, and air temperatures were recorded using a mercury-in-glass thermometer. Water samples were collected just below the water surface for the determination of salinity (refractometer) and pH (Jenway pH-meter) in the laboratory and dissolved oxygen (DO) concentration (Jenway DO-meter) in the field.

Laboratory procedures

The preserved specimens were thawed and wiped dry before laboratory analysis. The standard and total lengths (in centimeters) were measured on a measuring board and the weights (in grams) were determined using a sensitive Sartorius electric balance (Model 1106).

Diversity metrics

The study recorded a set of metrics including species abundance and taxonomic diversity. The set included Shannon Weiner, Dominance, Margalef, Evenness, Arithmetic abundance and Equitability indices. The highest diversity indices during the dry season (Simpson(1-D):0.89;H: 2.31; E: 0.91) were recorded in January 2019 (Table 1) and highest values (Simpson(1-D):0.87;H: 2.21; E: 0.83) were recorded in July 2018 during the wet season.

Table 1: Fish species Diversity of Dry seasons

Index	Jan, 2018	Jan, 2019	March, 2018	March, 2019	Nov, 2017	Nov, 2018	Dry Season
Taxa_S	12.00	11.00	9.00	8.00	5.00	9.00	27.00
Individuals	224.00	182.00	117.00	94.00	134.00	119.00	855.00
Dominance_D	0.11	0.11	0.19	0.13	0.39	0.14	0.07
Simpson_1-D	0.89	0.89	0.81	0.87	0.61	0.86	0.93
Shannon_H	2.29	2.31	1.82	2.04	1.05	2.09	2.92
Evenness_e^H/S	0.83	0.91	0.69	0.96	0.57	0.90	0.69
Margalef	2.03	1.92	1.68	1.54	0.82	1.67	3.85
Equitability_J	0.92	0.96	0.83	0.98	0.65	0.95	0.89

Table 2: Diversity of wet season

Index	July, 2018	July, 2017	Sept, 2017	Sept, 2018	May, 2019	May, 2018	Wet Season
Taxa_S	11.00	4.00	4.00	5.00	7.00	7.00	20.00
Individuals	117.00	67.00	44.00	42.00	211.00	219.00	678.00
Dominance_D	0.13	0.28	0.41	0.21	0.29	0.28	0.15
Simpson_1-D	0.87	0.72	0.59	0.79	0.71	0.72	0.85
Shannon_H	2.21	1.34	1.12	1.60	1.48	1.51	2.27
Evenness_e^H/S	0.83	0.95	0.77	0.99	0.63	0.65	0.48
Margalef	2.10	0.71	0.79	1.07	1.12	1.11	2.91
Equitability_J	0.92	0.96	0.81	0.99	0.76	0.78	0.76

Table 3: Fish Species Abundance for Dry and Wet Seasons

FAMILY	SPECIES	Abundance	NO INDEX	OF WET	DRY
Sphyraenidae	<i>Baracuda</i>	9	0.57		1.05
Haemulidae	<i>Brachydeuteurus auritus</i>	24	1.53		1.75
Carangidae	<i>Caranx hippos</i>	71	4.53		8.30
Claroteidae	<i>Chrysichthys nigrodigitatus</i>	232	14.77	16.88	13.45
Paralichthyidae	<i>Citharichtys stampflii</i>	34	2.17		3.97
Cynoglossidae	<i>Cynoglossus browni</i>	24	1.53		2.80
Cynoglossidae	<i>Cynoglossus senegalensis</i>	21	1.34	1.44	1.28
Muraenesocidae	<i>Cynoponticus ferox (costa)</i>	30	1.91	4.32	
Soleidae	<i>Dagetichthys lakdoensis</i>	5	0.32	0.75	
Dasyatidae	<i>Dasyatis garouaensis (ray)</i>	7	0.45	0.45	
Ctenoluciidae	<i>Dolophos boulengeri</i>	6	0.38	0.86	
Elopidae	<i>Elops lacerta</i>	30	1.91	0.57	3.04
Belonidae	<i>Ephippion guttifer (Puffer Fish)</i>	19	1.21	0.57	1.75
Clupeidae	<i>Ethmalosa fimbriata</i>	169	10.76	1.327	9.00
Gerreidae	<i>Eucinostomus melanopterus</i>	129	8.22		7.01
Elopidae	<i>Goby gobiidae (bathygobius soporator)</i>	16	1.02	1.87	0.35
Mormyridae	<i>Hyperopisus bebe</i>	14	0.89	2.02	
Mugilidae	<i>Liza falcipinnus</i>	137	8.72	6.35	10.29
Lutjanidae	<i>Lutjanus goreensis</i>	21	1.33		2.45
Mugilidae	<i>Mugil cephalus</i>	90	5.73	2.45	8.53
Ophichthidae	<i>Mystriophis creutzbergii (RED EEL)</i>	6	0.38		0.70
Notopteridae	<i>Papyrocranus afer</i>	15	0.95		1.75
Sciaenidae	<i>Pellonula afzeliusi</i>	13	0.83		1.40
Polynemidae	<i>Polydactylus quadrifilis</i>	51	3.24	1.88	4.44
Cynoglossidae	<i>Pomadasyis jubenini</i>	28	1.78	1.87	1.75
Monodactylidae	<i>Psettias sabae</i>	31	1.97	0.72	3.04
Sciaenidae	<i>Pseudolithus elongatus</i>	229	14.58	28.86	3.39
Clupeidae	<i>Sardinella madrensis</i>	37	2.35	1.44	3.15
Cichlidae	<i>Sarotherodon galileaus</i>	12	0.76	1.73	
Cichlidae	<i>Sarotherodon melano</i>	22	1.40		2.57
Belonidae	<i>Stronylura senegalensis</i>	20	1.27		2.33
Notopteridae	<i>Tetraodon lineatus (Dagger tooth Anoto</i>	2	0.12		0.23
Cichlidae	<i>Tilapia guineensis</i>	15	0.96	2.16	
Cichlidae	<i>Tilapia zilli</i>	1	0.06		0.11

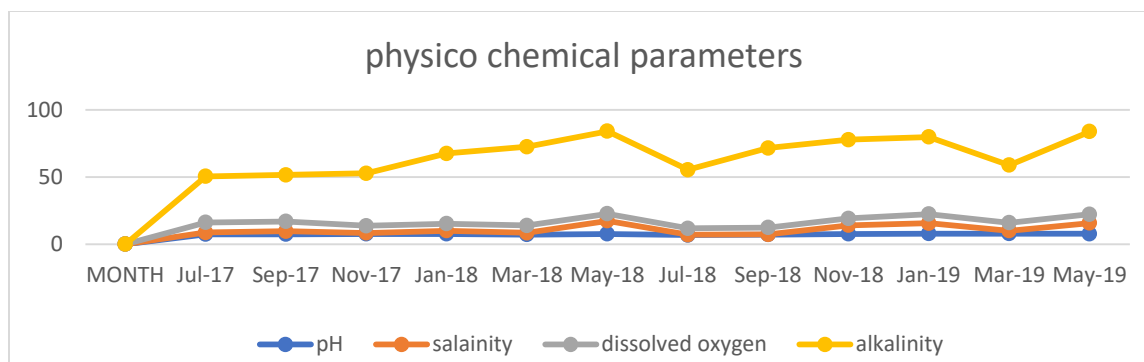


Figure 1: Physico-chemical parameters for 24 months July 2017-May 2019 from Badagry creek.

Results and Discussion

Water pH values were similar in all samplings, ranging from 6.7 to 7.83. Dissolved oxygen values ranged between 5.2 to 7.5, salinity was highest in May 2018, followed by January 2019. Salinity was slightly higher during the wet season than dry season (3.91; 3.37), in the months of May 2018 and May 2019 (9.77; 8), this may be due to high tide salt ingress from the sea through the harbor, this aligned with Soyinka et al 2010 that reported the influence of Lagos harbor and Cotonuu have on Badagry Creek

Biotic indices

A total no of 1570 catch value, belonging to 26 families and 34 species, was recorded during the period of sampling July 2017 to May 2019, 14 species belonging to 12 families were frequent during both seasons. The statistical analysis using T-test showed that there was significant difference in the abundance and occurrence of some species (*Chrysichthys nigrodigitatus*, *Cynoglossus senegalensis*, *Eucinostomus melanopterus*, *Ethmalosa fimbriata*, *Polydactylus quadrifilis*, *Sardinella madrensis*, *Pomadasys jubenini*) in wet and dry seasons. The specie *Chrysichthys nigrodigitatus* was present and classified higher abundant and frequent in almost all the study period being characterized, as important components of ichthyofauna assemblage in Badagry creek. The families with the highest percentage number were, Claroteidae, (232 individuals; 14.77%) Clupeidae (219 individuals 13.93%), Gerreidae (129 individuals; 8.21%), Mugilidae (227 individuals; 14.45%), Sciaenidae 229 individuals; 14.58%) (Table 3). The relative important index, 5 species were classified as higher abundant and frequent, representing 56.79% of sampled individuals. Margalef richness index ranged from 0.71 to 2.10, with higher value during the dry season, Evenness was higher during the dry season (0.69) than wet season (0.48). The Shannon diversity index varied from 1.05 to 2.29. In comparison to assemblages, higher values of richness and taxonomic diversity were found during the dry season than the wet season. There were non-significant difference among the diversity indices values in both seasons. The fish diversity found in Badagry creek is similar to Agboola *et al.* (2008) who documented 37 fish species and 28 families. It also compared favourably with Ajani and Balogun 2015 who documented 36 species and 22 families in Badary Creek. The dominance pattern found in fish assemblages of Badagry creek is probably seasonal and habitat type related, as some of the dominant species share the same food resources, such planktonic plants, sessile and mobile invertebrates, this finding aligned with the previous work of Eduardo et al 2018, that had dominant pattern of demersal fish assemblages of Brazilian continental shelf related to habitat type.

References

- Agboola, J.I and Anetekhai, M.A, (2008) Length-Weight Relationships of some fresh and brackish water fishes in Badagry creek, Nigeria. *J. Applied Ichthyol*; 24:623-625
- Ajani E.K, Balogun K.J (2015) Assessment of the impact of Abiotic factors of the fish assemblages in atropical estuary creek, *Scientific Journal Of Environmental Science* 4(2) 72-88
- Alexander, T.J., Vonlanthen, P., Periat, G., Degiorgi, F., Raymond J.C., Seehausen O. (2015). Evaluating gillnetting protocols to characterize lacustrine fish communities. *Fisheries Research* 161 (2015) 320-329.
- Beaugrand, G, Luczak, C., Goberville, E., Kirby, R.R., (2018). Marine biodiversity and the chessboard of life. E0194006. *PLoS ONE* 13(3).

- Carpenter, K.E and De Angelis, N.eds.(2016). *The Living Marine Resources of the Eastern Central Atlantic volume 4: Bony fishes part 2 (Perciformes to tetraodontiformes) and sea turtles. FAO species identification Guide for fishery purposes, Rome, FAO Pp 2343-3124.*
- Eduardo, L. N., Fredou, T., Lira, A.S.,Ferreira, B.P., Bertrand, A., Menard, F., Fredou, F.L.2018.*Continental Shelf Research*, S0278-4343(18)30070-0.
- Murillo, F.J, Kenchington,E, Koen-Alonso,M, Guijarro, J. Kenchington,T.J, Sacau,M,Beazley,L, Rapp, H.T. (2020).Mapping benthic ecological diversity and interactions with bottom-contact fishing on the Flemish Cap (northwest Atlantic). *Ecological Indicators* 112(2020) 106135.
- Olaosebikan, B.D., and Raji, A., (2013). *Field guide to Nigerian freshwater fishes*, ISBN 978-34 760-0-9 pp144
- Pielou, E.C., 1975. *Ecological diversity*, Wiley, New York, vii+165pp.
- Shannon, C.E, Weaver,W.,(1949).The mathematical theory of communication. *Math. Theory commun.* 27,117.
[Http://dx.doi.org/10.2307/3611062](http://dx.doi.org/10.2307/3611062).
- Vander Zanden,M.J., Vadeboncoeur,Y., (2002). Fishes as integrators of benthic and pelagic food webs in lakes. *Ecology* 83,2152-2161.

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Heavy Metals Bioaccumulation in Gills and Liver of *Chrysichthys nigrodigitatus* from Ankobra Estuary in Ghana

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Abstract

Illegal small scale gold mining known as “Galamsey” within the Ankobra Estuary has impacted the water quality and health of fish as well as other aquatic organisms. This paper reports on a recent study to investigate the concentrations of mercury and lead in water, sediments and organs of *Chrysichthys nigrodigitatus* from the Ankobra Basin. Bimonthly sampling (December, 2020 – June, 2021) was conducted at 9 sampling points along the Basin. Physicochemical parameters such as temperature, dissolved oxygen, pH and turbidity were measured. A total of 36 water samples, 36 sediment samples and 120 fish samples were collected. Samples were labelled and stored in ice chest to maintain the freshness and immediately transported to the laboratory where they were frozen at -4°C for further analysis. Results showed that physicochemical parameters of water were within range of fish survival except for turbidity. Water, sediments and fish samples were analysed for mercury (Hg) and lead (Pb) level using Atomic Absorption Spectrometry (AAS). Results were compared with international standards and most were found to be above thresholds. Further results showed that bioaccumulation factor in fish recorded higher values of Hg and Pb than in water. The research revealed that fishes from the Ankobra Estuary is polluted with Pb and Hg. This work will contribute to the knowledge of water quality implications on the Ankobra Estuary which empties directly into the ocean. It is recommended that government should make stringent guidelines on the activities of artisanal miners in the area.

Keywords: Ankobra Estuary, Artisanal mining, *Chrysichthys nigrodigitatus*, Heavy metals

Introduction

Heavy metals constitute a core group of aquatic pollutants due to their bio-accumulative and non- biodegradable properties. The environment is exposed to various doses of toxic heavy metals from activities such as mining, smelting, agriculture, domestic waste, sewage, and from industrial discharges and Ghana is not an exception (Al Bakheet *et al.*, 2013). In Ghana, Ankobra Basin is majorly associated with illegal small-scale gold mining activities called Galamsey, agricultural practices and indiscriminate disposal of waste. These activities are detrimental to the environment, especially the water bodies and the most hazardous pollutants from the activities are heavy metals such as mercury, lead, cadmium, selenium, copper, chromium, and arsenic (Gilbert and Osei-Bonsu, 2016). Fish can bioaccumulate heavy metals and biomagnify them in the food chain, making them useful in environmental biomonitoring (King and Jonathan, 2003). As a result of their various physiological activities, aquatic animals (including fish) bioaccumulate metals in large concentrations and store them especially in liver and gills for a long period of time (Obasohan, 2008). Little is known about heavy metal bioaccumulation in gills and liver of *C. nigrodigitatus* in Ankobra Estuary. Hence, the need for the study of mercury and lead bioaccumulation in gills and liver of *C. nigrodigitatus* from Ankobra Estuary. The purpose of the study is to investigate the concentrations of mercury (Hg) and lead (Pb) in water, sediments and organs of *Chrysichthys nigrodigitatus* from the Ankobra Estuary. Objectives are (i) to determine the physicochemical parameters of Ankobra Estuary (ii) to determine mercury and lead concentrations in water, sediments and *C. nigrodigitatus* samples from Ankobra Estuary (iii) to determine the bioaccumulation factor in gills and liver of *C. nigrodigitatus* from Ankobra Estuary.

Materials and Methods

The Ankobra Basin is one of the south-western basins of Ghana. It is located within latitudes 4°52'N–6°27'N, and longitudes 1°42'W–2°33'W. It is bounded to the East, West and South by the Pra Basin, Tano Basin, and the Gulf of Guinea respectively (Asare and Adimado, 2016). Water and sediment sampling was done at three sampling stations with sampling at three points in each station making a total of nine sampling points while fishes (*Chrysichthys nigrodigitatus*) were bought from the fishermen at the Ankobra harbour. Physicochemical parameters of temperatures, pH, salinity and dissolved oxygen were measured *in-situ* using EUTECH Multi-Parameter probe (PCD650). Ekman grab was deployed into the river for sediment collection. Water samples were collected below 15cm into the river. A total of 36 water samples, 36 sediment samples and 120 fish samples were collected

throughout the study. Samples were labelled and stored in ice chest to maintain the freshness and immediately transported to the laboratory where they were frozen at -4°C for heavy metal analysis. Mercury and Lead concentrations were determined in all samples using Atomic Absorption Spectrometry. The bioaccumulation factor of the fish was also calculated and it is the ratio of concentration of metals in fish tissues to abiotic media. Abiotic media represents water and sediment (Barron, 1990). One way and Two-way ANOVA were used for statistical analysis using Excel 2008 and Minitab 2010.



Figure 1: Map of Ankobra Estuary showing the sampling points

Results

Physicochemical Parameters

Salinity was generally low (< 0.9 ppt) in station 2 and station 3 and the highest values of salinity were recorded in station 1. The temperature in all stations was within range of $27 - 32^{\circ}\text{C}$. Dissolved oxygen recorded showed that there were temporal fluctuations in all of the stations, with values varying throughout the months. Mean DO values range from $5.38 \text{ mg/L} - 7.37 \text{ mg/L}$. There is no significant difference between the station ($P > 0.05$). Mean pH values range between $6.64 - 8.26$ for all the sampling months. There were fluctuations in the turbidity values throughout the period of study with the mean values ranging from $20 - 464 \text{ NTU}$ with high turbidity at Station 3. Station 1 had a low value compare to other stations in all the months and statistically showed that there was a significant difference between stations ($P < 0.05$).

Heavy Metal Concentrations

In water samples collected throughout the study period, mean levels of mercury (Hg) ranging from $0.002 - 0.018 \text{ mg/L}$ and lead (Pb) ranging from $0.13 - 1.5 \text{ mg/L}$ were above the recommended standards by WHO (2011) of 0.001 mg/L for Hg and 0.01 mg/L for Pb respectively. They also exceed the guidelines for protection of aquatic life 0.01 mg/L and 0.0025 mg/L (USEPA, 2007). In the sediment sample, mean mercury levels during the study period range from $0.47 - 9.8 \text{ mg/Kg}$ which was above the recommended level of 0.3 mg/Kg set by USEPA (2012) maximum permissible limit while mean levels of lead were below the recommended level of 40.0 mg/Kg set by USEPA (2012) maximum permissible limit ranging from $0.16 - 17.32 \text{ mg/Kg}$. In fish samples, the mean mercury levels in the liver of *Chrysichthys nigrodigitatus* for all the sampling months was 1.504 mg/Kg above the recommended level of 0.002 mg/L USEPA (2002) maximum contaminant level goal (MCLG). In gills, mean mercury levels was 1.930 mg/Kg also above the 0.002 mg/L USEPA (2002) MCLG. The mean lead level in the gills and liver of *Chrysichthys nigrodigitatus* are 0.68 mg/Kg and 0.814 mg/Kg respectively for the period of study which were above the recommended level of 0 mg/l set by (USEPA, 2002) maximum contaminant level goal.

Bioaccumulation Factor in *C. nigrodigitatus*

The bioaccumulation factor of Hg and Pb from water and sediments in gills and liver of *Chrysichthys nigrodigitatus* throughout the studies period are shown in Table (1). The results showed that the bioaccumulation factor of Hg in fish tissues from water were greater than that from sediment. BAF of Pb showed higher value in fish tissues from sediments than that from water except for June, 2021.

Table 1: Bioaccumulation Factor (BAF) of Hg and Pb(mg/Kg) in gills and liver of *C.nigrodigitatus* from AnkobraEstuary.

Month	Parameter	Hg (mg/Kg)	Pb (mg/Kg)
December, 2020	Gills/Water	13.5	4.82
	Gills/Sediment	0.82	27.2
	Liver/Water	14.2	2.59
	Liver/Sediment	2.49	13.27
February, 2021	Gills/Water	38.16	0.78
	Gills/Sediment	5.08	6.0
	Liver/Water	85.13	1.45
	Liver/Sediment	11.35	11.09
April, 2021	Gills/Water	732	1.61
	Gills/Sediment	25.77	37.8
	Liver/Water	416	3.1
	Liver/Sediment	14.65	73
June, 2021	Gills/Water	282.5	13.68
	Gills/Sediment	14.3	10.09
	Liver/Water	375	10.9
	Liver/Sediment	18.99	8.05

Discussion

Physicochemical Parameters

The quality of water is defined by a set of general parameters, such as dissolved oxygen (DO), alkalinity, pH, hardness, conductivity, salinity, and turbidity (Lawson, 2021). In this study, temperature, dissolved oxygen, pH and salinity were within range for aquatic survival (Water Resource Commission, 2009) except for turbidity. The mean turbidity levels recorded high values in AnkobraBasin throughout the study period ranging from 20 – 464 NTU. Okyere (2015) reported a similar study of high turbidity in the Pra Estuary associated with mining activities, with levels exceeding 150 NTU for most parts of the year.

Heavy Metals Concentrations

The concentration of Hg in water from Ankobra Estuary was above 0.001mg/L set by WHO (2011) standard limit for drinking water and USEPA (2007) guidelines for the protection of aquatic life. A similar study in Pra River Basin recorded high Hg levels (>0.03mg/L) which were above the standard limit of WHO and USEPA (Donkor, 2006). The level of Hg in sediments was higher than that of water and this could be due to sediments serving as reservoirs for contaminants (Suresh, Sutharsan, Ramasamy and Venkatachalapathy, 2012). The mean concentration of Hg in the gills and liver of *C. nigrodigitatus* samples was above the 0.002mg/Kg USEPA (2002) maximum contaminant level goal. The high values could be related to their tendency to accumulate more since they are at the top of the food pyramid. Oppong *et al.*, (2010) reported higher concentrations of Hg level in *C. nigrodigitatus* compared to other species in the study with increasing trophic levels.

The lead levels in water samples were above the WHO (0.01mg/L) and USEPA guidelines (0.0025mg/L) for drinking water and protection of aquatic life. The concentrations in the sediment were higher than in the water, which could be due to suspended heavy metals in the water column settling in the sediments and accumulating over time. In contrast, Obodia *et al.*, (2011) reported greater concentrations of metal in sediment than in water from Benya and Nakwoa Lagoon. The levels of Pb in sediments from AnkobraBasin recorded were below the USEPA maximum permissible limit of (40mg/Kg). For the whole sampling month, lead levels in *Chrysichthys nigrodigitatus* gills and liver were higher than the USEPA's maximum contaminant level target of 0mg/L (USEPA, 2002). However, Agency for Toxic Substances and Disease Registry (ATSDR, 2007) states that there is no safe level of Pb concentrations. This indicates that lead levels in the fish in this study are exceedingly high, which could be detrimental to fish health as well as making them unfit for human consumption.

Bioaccumulation Factor

Gills and liver of *C. nigrodigitatus* from AnkobraBasin accumulated more Hg in water than from sediments throughout the study period while Pb accumulated more Hg from sediment than in water for all the sampling months

except for June, 2021. This implies that the fish accumulated Hg more from water while Pb was assimilated more from sediment. The high levels of Hg could be associated with the Galamsey activities around Ankobra Basin. High mercury levels were also recorded by Dolbec *et al.* (2001) in water, mainly nearby gold extraction locations and industrial zones. High levels of Pb may be attributed to the presence of agricultural discharges, motor boat traffics and also from small-scale mining operations from the community. BCF obtained for Pb and Hg in both gills and liver of *C. nigrodigitatus* were all greater than the USEPA (2002) maximum contaminant level goal which indicated that the metals were highly bioaccumulated and biomagnified (Falusi and Olanipekun 2007).

Conclusion

The concentration of heavy mercury and lead in water, sediments, and fish samples exceeded the limits of the international standard set by WHO for drinking water and USEPA for the protection of aquatic life. It could be concluded that the water and fish in Ankobra Estuary are polluted with Pb and Hg.

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References

- Al Bakheet, S. A., Attafi, I. M., Maayah, Z. H., Abd-Allah, A. R., Asiri, Y. A., & Korashy, H. M. (2013). Effect of long-term human exposure to environmental heavy metals on the expression of detoxification and DNA repair genes. *Environmental pollution*, 181, 226-232.
- Asare-Donkor, N. K., & Adimado, A. A. (2016). Influence of mining related activities on levels of mercury in water, sediment and fish from the Ankobra and Tano River basins in South Western Ghana. *Environmental Systems Research*, 5(1), 1-11.
- ATSDR. (2011). Agency for Toxic Substances and Disease Registry, 4770 Buford Hwy NE Atlanta, GA 30341. (Oct 2011 update).
- Barron, M. G. (1990). Awua Bioconcentration. Will water-borne organic chemicals accumulate in aquatic animals *Environmental Science & Technology*, 24(11), 1612-1618.
- Dolbec, J., Mergler, D., Larribe, F., Roulet, M., Lebel, J., & Lucotte, M. (2001). Sequential analysis of hair mercury levels in relation to fish diet of an Amazonian population, Brazil. *Science of the total environment*, 271(1-3), 87-97.
- Donkor, O. N., Henriksson, A., Vasiljevic, T., & Shah, N. P. (2006). Effect of acidification on the activity of probiotics in yoghurt during cold storage. *International Dairy Journal*, 16(10), 1181-1189.
- Falusi, B. A., & Olanipekun, E. O. (2007). Bioconcentration factors of heavy metals in tropical crab (*Carcinus*) from River Aponwe, Ado-Ekiti, Nigeria.
- Fondriest Environmental Inc. (2013b). pH of Water - Fundamentals of Environmental Measurements.
- Gilbert, D., & Osei-Bonsu, A. (2016). Illegal small-scale gold mining in Ghana: A threat to food security.
- King, R. P., & Jonathan, G. E. (2003). Aquatic environmental perturbations and monitoring. *African experience, USA*, 166.
- Lawson, E. O. (2011). Physico-chemical parameters and heavy metal contents of water from the Mangrove Swamps of Lagos Lagoon, Lagos, Nigeria. *Advances in biological research*, 5(1), 8-21. Lewis Publishers, Boca Raton, FL. 1995;652-666
- Obasohan, E. E. (2008). Bioaccumulation of chromium, copper, manganese, nickel and lead in a freshwater cichlid, *hemichromis fasciatus* from Ogbia River in Benin City, Nigeria. *African Journal of General Agriculture*, 4(3), 141-152.
- Obodia, E. A., Boamponsem, L. K., Adokoh, C. K., Essumang, D. K., Villawoe, B. O., Aheto, D. W., & Debrah, J. S. (2011). Concentrations of heavy metals in two Ghanaian Lagoons. *Arch. Appl. Sci. Res*, 3(3), 177-187.
- Okyere, I. (2015). *Assessment of aquatic ecosystems, the fishery and socio-economics of a coastal area in the Shama district, Ghana*. Unpublished PhD thesis, Department of Fisheries and Aquatic Sciences, University of Cape Coast.
- Oppong, S. O. B., Voegborlo, R. B., Agorku, S. E., & Adimado, A. A. (2010). Total mercury in fish, sediments and soil from the River Pra Basin, southwestern Ghana. *Bulletin of Environmental Contamination and Toxicology*, 85(3), 324-329.

- Suresh, G., Sutharsan, P., Ramasamy, V., & Venkatachalapathy, R. (2012). Assessment of spatial distribution and potential ecological risk of the heavy metals in relation to granulometric contents of Veeranam lake sediments, India. *Ecotoxicology and Environmental Safety*, 84, 117-124.
- United States Environmental Protection Agency. (2007). The National Water Quality Inventory, Report to Congress for the 2002 Reporting Cycle- A profile” Fact Sheet No. EPA 841-F-07-003, Washington, D.
- United States Environmental Protection Agency. (2012). Water: Marine Debris. Environmental Protection Agency, Office of Water, Washington, DC.
- USEPA (United States Environmental Protection Agency. (2000). Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories: Volume 1, Fish Sampling and Analysis 3rd Edition, Office of Science and Technology of Water, Washington, DC EPA 823-B-00-007: 1-200.
- Water Resources Commission, 2009. Ankobra River Basin – Integrated Water Resources Management Plan
- World Health Organization (2011). Guidelines for Drinking Water Quality, 4th edn. Geneva, World Health Organization.

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The Ecological Survey of Fish Species in Lagos Lagoon

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Abstract

The ecological survey of fish species in some section of Lagos Lagoon was carried out. Fish samples were procured from fishermen in selected areas of the lagoon for a period of 12 months. Physico-chemical parameters which include temperature, dissolved oxygen, salinity, transparency, pH, total dissolved solids (TDS) and conductivity were taken in-situ using multi-meter, the mean values were recorded in all sampling stations for 12 months. The fish samples were allowed to thaw, sorted and identified using the recent FAO fish identification guide. There were twenty-five families of fish belonging to forty-six (46) fish species belonging to various fish families were recorded for the entire sampling period with a total weight of approximately 113kg. The most abundant species (by weight) recorded were *Chrysichthys nigrodigitatus*, followed by *Sardinella maderensis*, while, least species recorded were *Drepane africana* and *Electoris senegalensis*. The most abundance species (Number) recorded was *Sardinella maderensis*>*Chrysichthys nigrodigitatus*>*Eucinostomus melanopteron*>*Sarotherodon melanoteron*>*Sphyraena guanchanco*.. Most of the species were commercially important. The Physico-chemical parameters showed variations at different months and also at various stations. The study showed that the lagoon is very rich in diversity of living resources which is influenced by the physical characteristics of the aquatic environment.

Keywords: Lagos lagoon, Fish, Temperature, Salinity.

Introduction

The Lagos lagoon is surrounded by the metropolitan Lagos and receives a lot of anthropogenic input from households. Lagos metropolis have been reported to account for larger percentage of industries in Nigeria (Akinsanya, 2003; Oketola and Osibanjo, 2009a) and most of these industries discharge untreated effluent directly or indirectly through drainages and canals into the Lagos lagoon complex, thereby polluting the nursery ground of both fin-fishes and crustaceans (Oyewo, 1998; Adebayo *et al.*, 2007). Other sources of pollution in Lagos lagoon are hydrocarbons from oil pollution (Ekundayo, 1977), untreated faecal waste (Akinsanya, 2003; Kamaldeen and Wahab, 2011), Sewage and disposal of saw dust (wood waste) from sawmill industry situated at the fringes of the lagoon (Ekundayo, 1977; Nwankwo, 1998. Akpata, 2002; Dosunmu and Ajayi, 2002; Kamaldeen and Wahab, 2011), and industrial effluent (Oyewo, 1998 and Oketola, and Osibanjo, 2009b).

Fish, shell fish, benthic organisms and other living resources abundance and distribution have been affected by the pollution status of the lagoon. This lagoon is an important aquatic ecosystem in that it is rich in diversity of life forms and supports livelihood in terms of fishing, sand mining as well as transportation. As a result of these anthropogenic activities, the biodiversity of living species in the lagoon are endangered and critical habitats within the lagoon are been affected, the reason for this research is to assess the living resources and ecology on continuous bases so as to determine changes to the biotic component of the ecosystem.

Materials and Methodology

Sample Collection: The Fish samples were examined and purchased from different fishermen in different sections of Lagos lagoon during fishing hours, and preserved in ice chest for further analyses in the laboratory monthly between April, 2019 and July, 2020. The physico-chemical parameters were taken in-situ using multi-meter in all sample stations ; temperature was taken using thermometer, pH was taken with pH meter, conductivity, salinity and total dissolve solid were taken using Multi-meters, and transparency using secchi disc. The depth was taken using depth finder. Sediment sample collection and sieving were the last activity at each station, though during that time we often take transparency and depth because the fibre boat was more stable. The coordinates were taken using GPS.

Laboratory Analysis

The fish samples were sorted and identified using the recent FAO fish identification guide. The following data were collected from individual fish of the different species after measurement and dissection; morphometric and meristic measurement, sex, gonad stage (Reproductive Biology), Stomach content analyses (Feeding Ecology), and many others. Physico-chemical parameters were taken in-situ using multi-meter, the mean values were recorded at all stations for 12 months. The main parameters recorded were Temperature, Dissolved Oxygen, Salinity, Transparency, pH, Total Dissolved Solids (TDS) and conductivity.

Results

Fish Species

A total of forty-six (46) fish species belonging to various fish families were recorded for the entire sampling period with a total weight of approximately 113kg. The most abundant species (by weight) recorded was the *Chrysichthys nigrodigitatus* followed by *Sardinella maderensis* while least species recorded were *Drepane africana* and *Electoris senegalensis*. The top ten most abundant and least abundant of the species is as presented in Table 1. The abundance of all the species recorded in descending order is as shown in Figure 1. The mean values of various water physico-chemical parameters recorded at all stations and for various months are summarized in Table 2, with the highest and lowest mean values per month and per station. The mean water temperature was relatively high at around $29 \pm 5^\circ\text{C}$ and the mean salinity was highest in February and lowest in October, the mean Dissolved Oxygen was highest in January and lowest in October. Other parameters also showed variations that peaked and troughed at different months and also at various stations.

Table 1: Top ten most abundant and least species recorded during the sampling period

S/N	Species	Abundance (kg)
1	<i>Chrysichthys nigrodigitatus</i>	28392
2	<i>Sardinella maderensis</i>	19772
3	<i>Mugil cephalus</i>	13113
4	<i>Sarotherodon melanotheron</i>	8775
5	<i>Lutjanus goreensis</i>	7141
6	<i>Caranx hippos</i>	5832.2
7	<i>Sphyrna baracuda</i>	3313
8	<i>Polydactylus quadriflis</i>	3118
9	<i>Pomadasy jubelini</i>	3104
10	<i>Hemichromis fasciatus</i>	2325
37	<i>Chaetodipterus goreensis</i>	102
38	<i>Pseudotolithus epipercus</i>	93
39	<i>Cynoglossus browni</i>	90
40	<i>Fistularia petimba</i>	75
41	<i>Cynoponticus ferox</i>	56
42	<i>Strongylura senegalensis</i>	51
43	<i>Dalophis bouligeri</i>	46
44	<i>Gobinoellus occidentale</i>	42
45	<i>Drepane africana</i>	1
46	<i>Electoris senegalensis</i>	1

Table 2: High and Low Values of Parameters Recorded Per Month and Per Station

PARAMETERS	MONTHS		STATIONS	
	HIGH	LOW	HIGH	LOW
WATER TEMP(°C)	January 2019	July 2020	Majidun	Osbourne
DO(mg/L)	January -2020	October 2019	Osbourne	Ajeginle
SALINITY(‰)	February 2019	October 2019	NIOMR Jetty	Egbin
TRANSPARENCY(m)	January -2020	October 2019	NIOMR Jetty	Majidun
pH	October 2019	May 2019	Osbourne	Oreta
TDS(mg/l)	November 2019	January 2020	Ikate	NIOMR Jetty
CONDUCTIVITY(uS/cm)	July 2020	January -2020	Osbourne	Liverpool

The monthly variations in the abundance of the fish species recorded is as shown in Figure 2 with the highest number of fish species (by weight was recorded in the month of June 2019 followed by the month of December 2019. Least abundance recorded per month were in the months of November 2019 and January 2020. There were no sampling for three months (March – May 2020) due to COVID'19 restrictions.

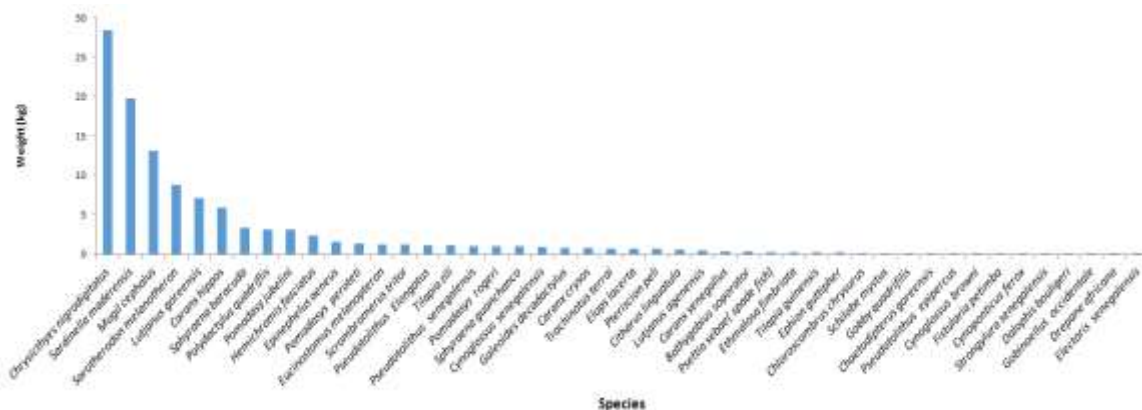


Figure 1: Abundance of fish species recorded in Lagos Lagoon (May 2019 – July 2020)

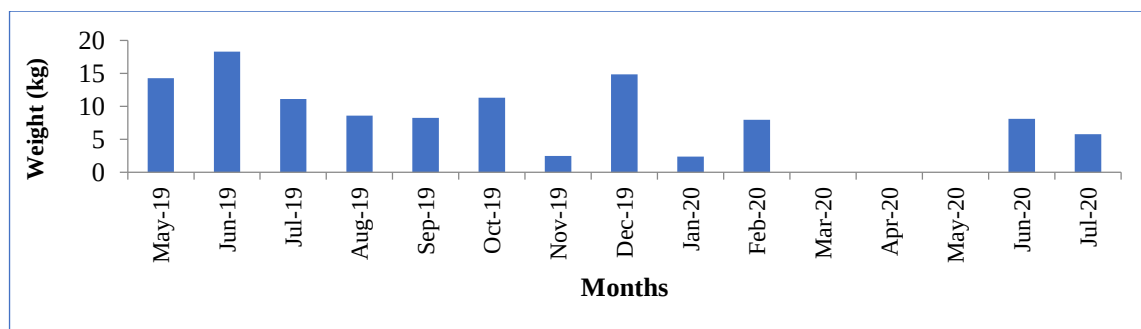


Figure 2: Monthly variation in abundance of fish species per month during the sampling period.

Discussion

The twenty-five families of fish belonging to forty-one species identified in this part of lagoon, showed the **species richness** in the lagoons. The higher number of fish families in Lagos Lagoon could have resulted from the level of high productivity of the lagoon, also exchange of species from Epe and Lekki Lagoons, possibly for the purpose of reproduction and feeding and resident species. The same result was also reported by [Olukolajo and Oluwaseun \(2008\)](#) and [Soyinka et al. \(2010\)](#). The physicochemical parameters results was affected by season during dry and wet season with higher and lower level respectively. Also the result was affected by the anthropogenic activities of the stations, the result indicated the

characteristics of a typical tropical water bodies and which corresponds to the normal seasonal weather of Nigeria. The same result was reported by Ladipo *et al.*, (2011) and Oyeleke *et al.*, (2019).

Conclusion

The study shows that the Lagos lagoon is very rich in diversity of living resources which is influenced by the physical characteristics of the aquatic environment.

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References

- Adebayo, O.T., Balogun, A.M. and Olubiyi, O.A. (2007). Chemical Analysis of some Industries; Discharge into Lagos lagoon. Nigeria. *Research Journal of Environmental Sciences*. 1(4): 196-199.
- Akinsanya, C.K. (2003). Recent trends in the pollution load on the Lagos Lagoon. – Lagos state perspective. A paper presented on ecological sustainable industrial development workshop organized by UNIDO.
- Akpata, T.V.I. (2002). *Aquatic Microbes: Impact on Man and environment*. An inaugural lecture delivered at the University of Lagos on 1st July, 2002. 40pp.
- Dosunmu, O.O. and Ajayi, A.B. (2002). Problems and management of sawmill waste in Lagos. Proceedings of International Symposium on Environmental Pollution Control and Waste Management. Tunis (EPCOWM'). 271-278pp.
- Ekundayo, J.A. (1977). Environmental consequences of the pollution of the Lagos lagoon. *Bulletin Science Association*. Nigeria 3: 290–299.
- Kamaldeen, O. S. and Wahab, B. (2011). The Impact of Excreta Disposal into Lagos Lagoon on the Lagoon Ecosystem at Iddo Discharge Point in Apapa Local Government Area of Lagos State Nigeria. *Journal of Sustainable Development and Environmental Protection*. 1: 1-7.
- Nwankwo, D. I. (1998). The influence of saw-mill wood wastes on Diatom population at Okobaba Lagos, Nigeria. *Journal of Botany*. 11: 16-24.
- Oketola, A.A. and Osibanjo, O. (2009). Estimating sectoral pollution load in Lagos by Industrial Pollution Projection System (IPPS): Employment versus Output. *Toxicological & Environmental Chemistry*. 91(5): 799-818.
- Olukolajo, S.O. and K.A. Oluwaseun, (2008). Seasonal variation in the distribution and fish species diversity of a tropical lagoon in South-West Nigeria. *J. Fish. Aquat. Sci.*, 3: 375-383.
- Oyewo, E.O. (1998). Industrial sources and distribution of heavy metals in Lagos lagoon and their biological effects on estuarine animals. Ph.D Thesis, University of Lagos, Nigeria. 279pp.
- Soyinka O.O., Kuton M.P., Ayo-Olalus C.I. (2010). Seasonal distribution and richness of species in the Badagry lagoon, South West, Nigeria. *Estonian Journal of Ecology*, 59(2): 147-157.

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Temporal occurrence of culturable heterotrophic bacteria and Total coliforms at the Commodore Channel of Lagos Lagoon

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Abstract

The aquatic microbes can greatly influence human and ecosystem health including food security. Environmental changes especially pollution disrupts the nature of these microbial attributes. Thus, this study monitored the monthly variation in the population of the culturable heterotrophic and coliform bacteria at a strategic point in Lagos Lagoon for twelve months for a better understanding of this important aquatic flora. The traditional spread plate and a Most Probable Number method was used to isolate and enumerate the heterotrophic and coliform bacteria respectively. The abundance of the heterotrophic bacteria during this study was obvious with the least and highest (8.15×10^3 and 1.58×10^5 cfu ml⁻¹) population occurring in December and January respectively, while very close population count was observed at the peak of rainy season. The population of coliform bacteria on the other hand, was highest in the month of September (675 cfu/100ml) and lowest in May (43 cfu/100ml). The presence of coliform bacteria suggests fecal pollution also the heterotrophic bacteria richness of this ecosystem confirms availability of organic matter alongside adequate cycling of nutrients. The physico-chemical parameters during the study period were all optimum for good microbial growth. Regular monitoring of a water body enables better understanding of the dynamics, general environmental health and early detection of ecological changes.

Keywords: Heterotrophic bacteria, Total coliform, Fecal pollution, Lagos Lagoon.

Introduction

The aquatic ecosystem is a treasured natural resource that provides food and recreation for mankind. Pollution of this environment due to human activities alongside climate change disrupts the structure and functions of fauna and flora leading to imbalances in the major roles of the ecosystem. Aquatic microbes play significant role are in productivity, biogeochemical cycling of nutrients and pathogenicity. Thus, they are major players in the sustainability of natural water bodies (Labbate *et al.*, 2016; Paruch *et al.*, 2019).

Heterotrophic bacteria are unicellular organisms, they have fast growth rates and respond rapidly to physical, chemical and biotic environmental changes including pollutants. They are mostly important in the mineralization and transformation of organic matter, through the utilization of organic matter for their energy and carbon source. Therefore, they provide sensitive and meaningful indications of ecological change (Tsai *et al.*, 2013; Yadav and Sharma 2020). On the other hand, the coliforms are primarily associated with the gastrointestinal tracts of warm-blooded animals, their presence indicates fecal pollution and presence of potential pathogenic microorganisms. Although they usually are not pathogenic, but frequently occur with potential pathogens such as Rotaviruses, Hepatitis A virus, Salmonella and others. Among the coliforms, *Escherichia coli* and *Enterococcus sp.* have long been used as fecal pollution indicators (Agwu *et al.*, 2020).

Generally, information of the microbiological status of an ecosystem helps in identifying impacts of anthropogenic activities and is also a good tool for biological water quality assessment and environmental health management. The main objective of this study was to monitor the microbiological health status of Lagos Lagoon at the Commodore Channel for a period of twelve months to understand the ecological dynamics for better environmental management and detection of any ecological change.

Materials and Methods

Sampling Point

The sampling point was at NIOMR Jetty which is a strategic part of the Commodore Chanel of Lagos Lagoon. It lies between longitude 003°24' 380"E and latitude 06°25' 234"N'. Activities around this point include fishing, dredging and open defecation.

Surface Water Physico-chemical Parameters

Surface water temperatures were measured using mercury-in-glass thermometer. Salinity, and pH were measured using a multi-parameter water checker (Horiba U-10). Dissolved oxygen (DO) was determined using iodometric Winkler's method (APHA, 1995).

Bacterial Isolation and Enumeration

The surface water samples were collected twice in a month from January to December. The samples were aseptically collected into sterile sampling bottles, which were transferred immediately to the laboratory for analysis. The population of heterotrophic bacteria was determined using spread plate method and the colony forming units (cfu) were counted after 18 to 24 h incubation at $28 \pm 2^\circ\text{C}$. The total coliforms were estimated using the five-tube most probably number (MPN) technique. The presumptive test for coliforms was carried out by inoculating the tubes of lactose bile broth with the appropriate water samples and incubating at 37°C . The tubes that showed gas production in the inverted Durham tubes after 24 - 48 h were noted as positive tubes and subsequently, aliquots (0.1ml) of cultures from these positive tubes were inoculated into brilliant green bile broth for the confirmed test. The number of tubes which indicated gas production (positive tubes) after the 24 h incubation was used to calculate the MPN.

Statistical Analysis of Data

The mean, standard deviation and correlation coefficients of the data generated were calculated using the Prism version 5.03 computer software programmes (GraphPad Software, San Diego, CA. USA).

Results

Surface Water Physico-chemical Parameters

The mean values of the dissolved oxygen, Temperature, Salinity and pH observed each month during the study period is shown in Table 1. Dissolved oxygen was relatively regular except lower values observed in April may and June. The salinity also reduced between July and September, while the temperature and pH did not show any obvious variation.

Table 1 Mean $\pm$ SD values of the Surface Water Physico-chemical Parameters

Sampling Month	Dissolved Oxygen (mg/L)	Temperature ($^\circ\text{C}$)	Salinity (ppt)	pH
January	6.22 $\pm$ 2.14	28.9 $\pm$ 0.76	29.41 $\pm$ 1.55	8.26 $\pm$ 0.19
February	6.8 $\pm$ 1.67	29.0 $\pm$ 0.88	30.5 $\pm$ 2.74	8.45 $\pm$ 0.13
March	5.2 $\pm$ 1.888	29.4 $\pm$ 0.66	32.9 $\pm$ 2.98	8.41 $\pm$ 0.18
April	4.8 $\pm$ 2	29.96 $\pm$ 0.43	28.6 $\pm$ 4.77	8.37 $\pm$ 0.14
May	3.88 $\pm$ 1.96	29.84 $\pm$ 0.41	25.04 $\pm$ 5.07	8.48 $\pm$ 0.16
June	2.86 $\pm$ 0.50	28.63 $\pm$ 0.59	25.51 $\pm$ 6.10	8.62 $\pm$ 0.13
July	5.72 $\pm$ 1.79	26.77 $\pm$ 0.74	11.57 $\pm$ 7.23	8.54 $\pm$ 0.18
August	6.63 $\pm$ 0.77	26.53 $\pm$ 0.87	19.21 $\pm$ 8.63	8.39 $\pm$ 0.07
September	6.24 $\pm$ 2.67	26.98 $\pm$ 1.12	18.19 $\pm$ 10.12	8.48 $\pm$ 0.12
October	6.77 $\pm$ 1.74	27.26 $\pm$ 2.98	21.82 $\pm$ 6.93	7.83 $\pm$ 0.40
November	6.46 $\pm$ 1.15	29.46 $\pm$ 1.10	28.01 $\pm$ 5.31	7.8 $\pm$ 0.16
December	5.95 $\pm$ 0.89	28.75 $\pm$ 1.16	28.71 $\pm$ 3.64	8.11 $\pm$ 0.13

Population of heterotrophic bacteria and total coliforms

The highest viable bacterial count (1.58×10^5 cfu ml⁻¹) was noted in January while the least (8.15×10^3 cfu ml⁻¹) was observed in December. The populations noted (4.63×10^4 , 4.73×10^4 , 4.53×10^4 cfu ml⁻¹) at the peak of rainy season June, July and August was almost the same then a gradual decline although still of the same order of magnitude (1.25×10^4 and 1.68×10^4 cfu ml⁻¹) occurred during the dry season months of October and November.

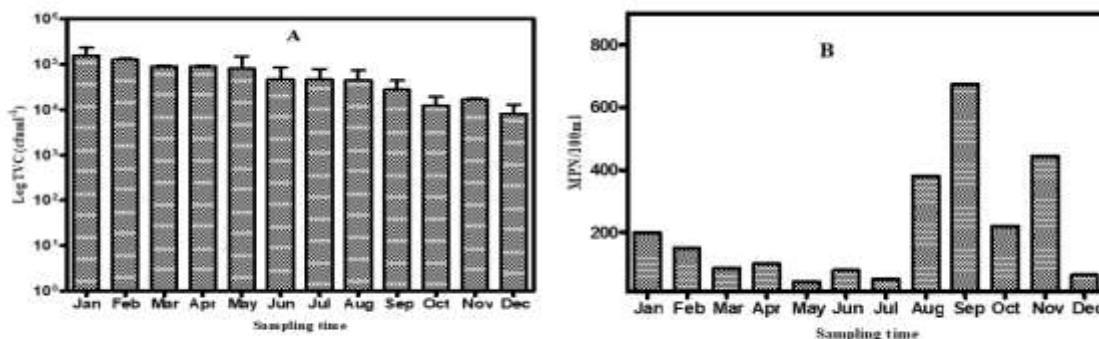


Figure 1 Population of Culturable Heterotrophic (A) and Total Coliform bacteria (B) during the study Period

The total coliforms population depicted in Figure 2 shows that the highest population (975 cfu/100ml) was noted in September. The MPN of 445 and 380 cfu/100ml observed in November and August were also relatively high. Nevertheless, during this sampling period, the least value (43 cfu/100ml) was noted in May.

Discussion

The values of the physico-chemical parameters observed in this study were ultimately within the optimal range for bacteria survival and growth. Therefore, the high population of heterotrophic bacteria noted were in accordance with the population range (3.3×10^5 to 1.61×10^5 cfu ml⁻¹) and (4.0×10^2 to 7.3×10^5 cfu ml⁻¹) for Douala Lagoon in Cameroon and Mullipallam Creek in southeast coast of India as reported by Akoachere *et al.* (2008), and Ashokkumar *et al.*, (2011) respectively. Heterotrophic bacteria represent the majority of aquatic biomass responsible for productivity and nutrient cycling. They are usually abundant in coastal areas due to availability of organic matter from terrestrial and anthropogenic sources (Labbate *et al.*, 2016). Adequate cycling of nutrients is expected in this environment if all other environmental factors are in order.

The population of the fecal microbial indicators observed indicates fecal pollution of the water; similar reports had been observed in different parts of the lagoon (Ajayi and Akonai 2005, Agwu *et al.*, 2020). Furthermore, it also corresponds with the population range earlier reported for other coastal waters (Akoachere *et al.*, 2008, Akoto *et al.*, 2010, Ashokkumar *et al.*, 2011). The detection of fecal microbial indicator in this study is expected since open defecation is a regular occurrence at this point of Lagos Lagoon. Human waste serves as a typical source of enteric and pathogenic microorganisms. (Ortega *et al.*, 2009). The values recorded in the present study however, are within the recommended value of 1000/100ml for recreational water, according to the US water standards (Atlas, 1997).

According to Roselli *et al.* (2009) coastal lagoons are among the most dynamic and complex aquatic environments on earth. The increasing anthropogenic activities around these ecosystems, including the constant inflow of domestic wastes produces high levels of pollution and constant decrease of water quality. Hence there is need for continuous monitoring of this environment for the detection of ecological changes and better environmental management system.

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References

- Agwu Ogochukwu A., Oluwagunke Theresa, Ebohon Joy O., Bello Beatrice O. and Yakub Ademola S. (2020). The Profile of Water Pollution Indicator Bacteria among other Heterotrophic Bacteria in Relation to Anthropogenic Activities in Lagos Lagoon. *Proceedings of 7th NSCB Biodiversity Conference*. Pp 86-91.
- Ajayi, A.O., Akonai, K. A. (2005). Distribution Pattern of Enteric Organisms in the Lagos Lagoon, Nigeria. *African Journal of Biomedical Research* 8: 163-168.
- Akoachere, J. T. K., Oben, P. M., Mbivnjo, B.S., Ndip, L.M., Nkwelang, G., Ndip, R. N. (2008). Bacterial indicators of pollution of the Douala lagoon, Cameroon: Public health implications. *African Health Sciences* 8: 85-89.
- Akoto, O., Bruce, T. N., Darko, G. (2010). Chemical and biological characteristics of streams in the Owabi watershed. *Environmental Monitoring and Assessment* 161: 413–422.
- Ashokkumar, S., Rajaram, G., Manivasagan, P., Ramesh, S., Sampathkumar, P., Mayavu, P. (2011). Studies on Hydrographical Parameters, Nutrients and Microbial Populations of Mullipallam Creek in Muthupettai Mangroves (Southeast Coast of India). *Research Journal of Microbiology* 6: 71-86.
- Atlas, R. M. (1997): Microbial ecology and Environmental Microbiology. *Principles of Microbiology*. Wm. C. Brown Publishers.
- Labbate, M., Seymour, J. R., Lauro, F., & Brown, M. V. (2016). Anthropogenic Impacts on the Microbial Ecology and Function of Aquatic Environments. *Frontiers in Microbiology*, 7(July), 6–8. <https://doi.org/10.3389/fmicb.2016.01044>
- Ortega, C., Solo-Gabriele, H.M., Abdelzaher, A., Wright, M., Deng, Y., Stark, L.M. (2009) Correlations between microbial indicators, pathogens, and environmental factors in a subtropical Estuary. *Marine Pollution Bulletin* 58: 1374–1381.
- Paruch, L., Paruch, A. M., Eiken, H. G., & Sørheim, R. (2019). Faecal pollution affects abundance and diversity of aquatic microbial community in anthropo- zoogenically influenced lotic ecosystems. *Scientific Reports*, 9, 1–13. <https://doi.org/10.1038/s41598-019-56058-x>
- Roselli L., Fabbrocini A., Manzo C., D’Adamo R. (2009). Hydrological heterogeneity, nutrient dynamics and water quality of a non-tidal lentic ecosystem (Lesina Lagoon, Italy). *Estuarine, Coastal and Shelf Science*. 84: 539–552.
- Tsai A.Y., Gong G.C. and Hung J. (2013). Seasonal variations of virus- and nanoflagellate-mediated mortality of heterotrophic bacteria in the coastal ecosystem of subtropical western Pacific. *Biogeosciences*, 10: 3055–3065.
- Yadav, N.; Sharma, S. (2020). Pollution shapes the bacterial community of a river: a case study. *International Journal of Environmental Science and Technology*, 17(4), 2003–2016. <https://doi.org/10.1007/s13762-019-02474-5>.

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Turning Adversity to Prosperity by Generating Wave Power from Ecological Devastation: A Case Study of Ayetoro, Ondo State, Nigeria”

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Abstract

Ayetoro, a fishing coastal community in Ondo State had experienced severe ecological devastation orchestrated by climate change. This work assesses the power generation potential of extreme significant wave height (SWH) within the return period of 2, 5, 10, 20, 50 and 100 years respectively, using Gumbel distribution scheme based on a 40-year (1980-2019) wave hind-cast. Iglesias's valuation method was adopted to calculate power density for extreme SWH. Values of 0.65 kW/m², 0.83 kW/m²; 0.87 kW/m²; 1.10 kW/m²; 1.24 kW/m² & 1.35 kW/m² was recorded in summer while lower values of 0.17 kW/m²; 0.21 kW/m²; 0.21 kW/m²; 0.26 kW/m²; 0.29 kW/m²; 0.32 kW/m² was recorded for winter for 5 years, 10 years, 25 years, 50 years and 100 years return periods respectively. The adverse extreme waves devastating Ayetoro could be exploited for power generation.

Key words: Wave, Energy, Potential, Ecology and Ayetoro.

Introduction

Wave power is a worldwide coastal resource estimated to be over two trillion watts which is limited in commercial use despite its high density per metre square (Czech *et al.*, 2012). For many years this source of energy was neglected until the 1973 oil crisis. However, with the increased appreciation of the negative effect of global warming majorly attributable to the use of fossil fuel, the need to develop cleaner and renewable energy has awakened the interest of some scientists in ocean wave energy for power generation. While wind and solar energy currently dominate the renewable market, they are available only 20 to 30% of the time in contrast to wave energy that is available 90% of the time. Heat emanating from the sun warms the atmosphere thereby producing temperature differentials of the air mass around the globe (Caires *et al.*, 2006; Christine, 2004). The movement of these air mass from hotter region to cooler regions produce wind. As this wind passes over the surface of the oceans, a portion of the wind kinetic energy is transferred to the water below generating waves. These waves often propagate long distances across the open sea with little loss of energy. At the shoreline, their speed is slowed down due to reduced water depth but they increase in spread and finally crash into the shoreline releasing enormous kinetic energy convertible into electrical energy (Günther *et al.*, 2008).

Materials and Methods

The version 3.14 of the third-generation spectral wave model WAVEWATCH IIITM (WW3), was used to simulate ocean wave parameters over the mid-Atlantic Ocean. Results over water are extracted over 60°W, 10°S, 15°E and 20°N which contains the study location defined by coordinates 4.77°E, 6.1°N. Extreme wave events for different return periods of extreme significant wave height (SWH) was extrapolated using the Gumbel distribution based on a 40 year (1980-2019) wave hind-cast. Wave energy was calculated using the equation derived from Linear Wave theory. The Linear Wave theory gives the wave energy as:

$$E = \frac{1}{16} \rho g H^2, \quad \dots \dots \dots (1)$$

where E is the mean wave energy density per horizontal area (J/m²), the sum of kinetic and potential energy, ρ the water density, g acceleration by gravity and H is the wave height;

$$P = E C_g \quad \dots \dots \dots (2)$$

With P as wave power and C_g as the group velocity (m/s). The wave energy is directly proportional to the square of wave height. Eq. (1); thus, the wave height can be used as a measure for wave energy (Bulteau *et al.*, 2013).

Results

Tables 1 and 2 presents the annual mean SWH and Extreme SWH(Forecast) mean Wave Power Density (kW/m) for different return periods. The overall annual mean wave power of 0.5 kW/m is compared with a 2-, 5-, 10-, 25-, 50- and 100-year future projection of wave power. It is observed that for the 5- to 100-year return periods, the wave power rises by 0.0662 kW/m, 0.0962 kW/m, 0.2362 kW/m, 0.3362 kW/m and 0.4062 kW/m. The 2-year projection value for the wave power declined by 0.054 kW/m from the overall annual mean value. The seasonal analysis is shown in tables 1 and 2. The overall winter mean wave power of 0.18 kW/m is compared with a 2-, 5-, 10-, 25-, 50- and 100-year future projection of wave power. It is observed that for the 5- to 100-year return periods, the wave power rises by 0.026 kW/m, 0.026 kW/m, 0.076 kW/m, 0.106 kW/m and 0.136 kW/m. The 2-year projection value for the wave power declined by 0.014 kW/m from the overall annual mean value. Also, for summer, the overall summer mean wave power of 0.73 kW/m is compared with a 2-, 5-, 10-, 25-, 50- and 100-year future projection of wave power. It is observed that for the 5- to 100-year return periods, the wave power rises by 0.1 kW/m, 0.14 kW/m, 0.37 kW/m, 0.51 kW/m and 0.62 kW/m. The 2-year projection value for the wave power declined by 0.08 kW/m from the overall annual mean value. The overall seasonal (Winter and Summer) average extreme SWH for different return periods are displayed in Figure 2b for Winter (November - March) and Figure 2c for Summer (April – October). For Winter, extreme wave events range between 0.75 m and 1.37 m from 2 years through 100 years return periods. The monthly variation of wave power in Figure 1 shows that higher values of 0.83 kW/m, 1.31 kW/m, 1.25 kW/m and 0.75 kW/m are observed in Summer months of June through September. Least values of 0.18 kW/m, 0.12 kW/m, 0.13 kW/m and 0.2 kW/m are seen in Winter months of November through February. In Figure 4, the annual mean wave power stands at 0.5 kW/m while the averages for Winter and Summer respectively stand at 0.18 kW/m and 0.73 kW/m. For all return periods, power density and hence power generation will be highest between the month of June to September, with peak periods occurring in July with a mean value of 1.35 Kw/m² (Fig. 1).

Table 1: Winter Mean and Extreme Wave Energy and Power for different return periods in Ayetoro

Return Period (Years)	Mean SWH	Mean Wave Energy	Mean Wave Power (kW/m)	Extreme SWH	Extreme Wave Energy	Extreme Wave Power (kW/m)
2	0.23	32.30	0.18	0.75	343.50	0.17
5	0.26	41.28	0.18	0.91	505.69	0.21
10	0.26	41.28	0.18	0.94	539.58	0.21
25	0.30	54.96	0.18	1.15	807.60	0.26
50	0.32	62.53	0.18	1.27	984.94	0.29
100	0.33	66.50	0.18	1.37	1146.15	0.32

Table 2: Summer Mean and Extreme Wave Energy and Power density for different return periods in Ayetoro.

Return Period (Years)	Mean SWH	Mean SWH Energy	Mean SWH Power (kW/m)	Extreme SWH	Extreme SWH Energy	Extreme SWH Power (kW/m)
2	0.45	123.66	0.73	1.28	1000.51	0.65
5	0.51	158.83	0.73	1.54	1448.25	0.83
10	0.53	171.54	0.73	1.60	1563.30	0.87
25	0.61	227.23	0.73	1.94	2298.29	1.10
50	0.67	274.10	0.73	2.15	2822.79	1.24
100	0.71	307.83	0.73	2.32	3286.82	1.35

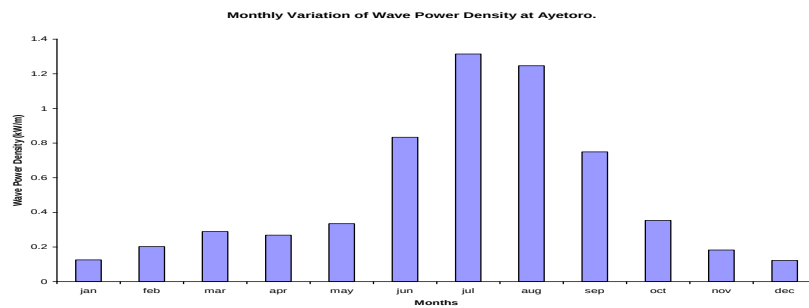


Fig 1: Monthly mean variation of power density.

Discussion

Results show clearly that the significant wave height computed by the model and the observed values are highly correlative with a correlation coefficient (cc) of 0.927 and significant at the 99% level. The calculated positive mean bias error (MBE) which is 0.094 m is quite low and showed that the buoy data is slightly underestimated. The error of model data which is 0.221 m is low when analyzed by the root mean square error (RMSE). In general, the simulation results are consistent with the observations, which show that WW3 can well reproduce the significant wave height and also a reliable model to model surface waves in the study area. Recent technologies have shown considerable prospect for the development of wind farms using medium size buoy-like WEC (Falnes, 2007). The commercial viability of wave energy has been demonstrated by Bombara wave power project based in Perth, Western Australia, CETO wind farm off the coast of western Australia, Agucadoura wave farm in Portugal, the wind farm in Scotland pioneered by the firm, Pelamis. The prospect for the development of a wind farm in Ayetoro could turn the devastating ravaging waves into a growth opportunity for the community. The power density for the study areas is between 0.45 to 0.91 kW/m² for the annual mean, 0.17 to 0.32 kW/m² for Winter and 0.65 to 1.35 kW/m² for Winter. The highest values for power density occurred between the months of June, July, August and September. With the renewed interest of the G-7 nations to drastically reduce global carbon emission and combat climate change impact, Nigeria could attract substantial foreign aid for this alternative energy source.

Conclusion

The current environmental challenges confronting Ayetoro community can be transformed into an opportunity for growth and development if requisite resources are channeled towards solving this ecological disaster. The high energy wave that characterizes the shoreline of the community could be converted to wave energy for electricity generation

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References

- Bulteau T, Lecacheux S, Nicolae L, Erma A, Paris F. 2013a. Spatial extreme value analysis of significant wave heights along the French coast.In:Actes from International Short Conference on Extreme Value Analysis and Application to Natural Hazards (EVAN 2013),Siegen,8–11 September,pp.46–56.ISSN1868-6613.
- Caires S, Swail VR, Wang XL. 2006. Projection and analysis of extreme wave climate. *Journal of Climate*, 19(21), pp.5581–5605.
- Christine Miller(August 2004). Wave and tidal energy experiments in San Francisco and Santo Cruz.
- Czech, B. Baner, P. (June 2012). Wave energy converter Concepts: Design Challenges and classification. IEEE Industrial Electronics Magazine G(2): 4-16. DOI:1109/MIE.2012.2193290.ISSN1932-4529;S2CID31096895.
- Falnes J. (2007) ‘A review of wave -energy extraction’ Marine Structures. 20(4) 185-201 DOI:10.1016/j.marstruc.2007.09.001.
- G~untherH, Rosenthal W, Schwarz M.(1998). “The wave climate of the northeast Atlantic over the period 1955–1994: the WASA wave hindcast,” *The Global Atmosphere and Ocean System*, vol. 6, pp. 121–163.

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Abundance and distribution of the Periwinkle species *Pachymelaniafusca* (Gmelin, 1791) of the Intertidal Mudflats of Calabar River

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Abstract

Studies on the abundance and distribution of *Pachymelania fusca* along the intertidal mudflats of Calabar River was carried out between July and September. Live periwinkles were sampled once a month from three stations and transferred to the laboratory for identification, grouping and enumeration. Results of analysis of variance revealed no significant monthly and grouped (smooth or wrinkled) differences ($p>0.05$) in the abundance of periwinkles. Average distribution of smooth periwinkles in the three stations were 81.00 (1.91%), 705.67 (16.62%) and 2146.33 (50.545); for partially wrinkled 72.67 (1.71%), 61.00 (1.44%), 433.33 (10.20%) while fully wrinkled samples were 49.67 (1.17%), 264.00 (6.22%), 433.00 (10.20%) respectively. There was significant difference in the distribution of periwinkle sampled which was attributed to anthropogenic activities within the river. The abundance and distribution of periwinkle in all the groups follow the same pattern of station3>station2>station1.

Keywords: Periwinkle, Species abundance, Mangrove swamps, Calabar River

Introduction

Pachymelania fusca is a genus of gastropod mollusk in the order Sorbeoconcha and family Thiariidae. This family is represented in the lagoons, estuaries and mangrove swamps by two genera (*Pachymelania* and *Tympanotonus*) and are usually harvested by handpicking (Adebayo *et al.*, 2011). *Pachymelania fusca* are not often found in the main body of water but are restricted to the mangrove swamp and mudflats. Its distribution frequently coincides with that of the *Tympanotonus fuscatus* and the two grouped together are called periwinkles in Nigeria (Egonmwan, 2007). Periwinkles constitute one of the relatively easily harvested shell fishes occurring widely within the upper intertidal zone of coastal areas. Bob-Manuel (2012) observed that *T. fuscatus* occurs in the littoral habitat while *P. fusca* colonize the subtidal and mud beaches. They affect benthic community structure and recruitment success of structurally important seaweeds (Trussell *et al.*, 2004). In view of the wide exploitation of periwinkle species due to their economic importance, there is need to assess their abundance and distribution on the intertidal mudflat of Calabar River to ascertain their ecological status.

Materials and methods

The study areas are located between latitude 04°30'13" N and longitude 08°30'06" E; and latitude 04°32'40"N and longitude 08°28'40"E. samples of periwinkle were collected once a month for three months from July to September by hand picking them along the mudflats of the Calabar River at the different sampling stations. The samples collected were stored in three sampling containers of ten-liter capacity each, labelled according to the sampling point and transported to the Institute of Oceanography Laboratory University of Calabar for identification. The samples were identified based on taxonomic guidelines of Bouchet and Pocroi (2005). The identified samples were separated into three different groups depending on the smoothness or wrinkling of the shell and then grouped as; "smooth", "partially wrinkled" and "fully wrinkled" in each station. Individual periwinkle grouped were counted and recorded according to the taxonomic group they belong. The relative abundance and distribution of each group was calculated respectively for each month and station according to the formula given by Jamabo and Alfred-Ockiya (2000) below:

$$\%RA = \frac{n(100)}{N} \text{ where } n \text{ is the number of a particular group, } N \text{ is total number of all individuals of a}$$

all groups and %RA is the relative abundance in percentage

Data obtained from the study were subjected to descriptive statistics for means, standard deviation and standard error of mean. Anova was used to test the significant variations in abundance and distribution of periwinkles between the three sampling stations. Variations with a probability level of $p<0.05$ was considered significant and further subjected to Duncan Multiple Test of difference to specify the source of variation.

Results

The periwinkle species distribution and abundance are presented in Table 1-4 below. Based on morphological identification, three varieties of periwinkle (*Pachymelania fusca*) were observed on the mudflat of Calabar River. These varieties were grouped into “smooth”, “partially wrinkled” and “fully wrinkled” respectively.

Table 1: Frequency distribution and abundance of periwinkle identified during the study

Months	Groups	S1	S2	S3	Total
July	Smooth	62	517	1915	2494
	Partially wrinkled	56	30	401	487
	Fully wrinkled	33	211	357	601
Total		151	758	2673	3582
August	Smooth	52	562	1842	2456
	Partially wrinkled	58	55	377	490
	Fully wrinkled	29	218	423	670
Total		139	835	2642	3616
September	Smooth	129	1038	2682	3849
	Partially wrinkled	104	98	522	724
	Fully wrinkled	87	363	519	969
Total		320	1499	3723	5542

Table 2: Percentage distribution and abundance of periwinkle identified during the study

Months	Groups	S1	S2	S3	Total
July	Smooth	1.73	14.43	53.46	69.63
	Partially wrinkled	1.56	0.84	11.19	13.60
	Fully wrinkled	0.92	5.89	9.97	16.78
Total		4.22	21.16	74.62	100.00
August	Smooth	1.44	15.54	50.94	67.92
	Partially wrinkled	1.60	1.52	10.43	13.55
	Fully wrinkled	0.80	6.03	11.70	18.53
Total		3.84	23.09	73.06	100.00
September	Smooth	2.33	18.73	48.39	69.45
	Partially wrinkled	1.88	1.77	9.42	13.06
	Fully wrinkled	1.57	6.55	9.36	17.48
Total		5.77	27.05	67.18	100.00

Table 3: Average monthly abundance of periwinkle species identified during the study

Groups	July Freq. (%)	August Freq. (%)	Sept. Freq. (%)	Total Freq. (%)
Smooth	831.33 (19.77%)	818.67(19.47%)	1283.00(30.51%)	2933.00 (69.74%)
Partially wrinkled	162.33 (3.86%)	122.50 (2.91%)	241.33 (5.74%)	526.17 (12.51%)
Fully wrinkled	200.33 (4.76%)	223.33 (5.31%)	323.00 (7.68%)	746.67 (17.75%)
Total	1194.00 (28.39%)	1164.50 (27.69%)	1847.33 (43.92%)	4205.83 (100.00%)

Table 4: Average spatial distribution of periwinkle species identified during the study

Groups	S1 Freq. (%)	S2 Freq. (%)	S3 Freq. (%)	Total Freq. (%)
Smooth	81.00 (1.91%)	705.67(16.62%)	2146.33(50.54%)	2933.00(69.07%)
Partially wrinkled	72.67 (1.71%)	61.00 (1.44%)	433.33 (10.20%)	567.00 (13.35%)
Fully wrinkled	49.67 (1.17%)	264.00 (6.22%)	433.00 (10.20%)	746.67 (17.58%)
Total	203.33(4.79%)	1030.67(24.27%)	3012.67(70.94%)	4246.67(100.00%)

Discussion

The distribution and abundance of the periwinkle species, *Pachymelania fusca* obtained from the mudflats of Calabar River at different sampling stations revealed significant spatial difference. This variability could be attributed to different ecological characteristics of the mudflats. The different stations are also subjected to different anthropogenic influence, as such the abundance and distribution are affected differently. This result is in line with the previous study of Ekpo *et al.*, (2015) who reported that periwinkles are bottom feeders and tend to be more

abundant under roots and decaying mangroves. This ecological characteristic is typical of sampling station three (3) where most of the periwinkle samples were picked under the roots and decaying mangrove plants during low tide. Other factors such as salinity, water depth, currents and nature of bottom deposits were highlighted by Bob-Manuel (2012) to affect their distribution in the coastal areas of West Africa. The abundance of periwinkle samples on the mudflat of station 3 was also reaffirmed by the study of Ajao and Fagade (1990) who observed the greatest densities of periwinkles at site further from anthropogenic inputs of sewage and industrial effluents and in sediments containing 6-40% silt-clay. The results of the present work also agree with that of Saier (2000) which reported that periwinkles can respond to differences in microhabitats and change their behavior in response to different environmental conditions including physiochemical parameters of habitat water. However, notwithstanding the levels of anthropogenic activities within the study area, periwinkles were still recorded in reasonable densities. The reason could be attributed to the ability of the periwinkles to contract faster and deeply up to $\frac{3}{4}$ into the shell and maintain a healthy condition in adverse periods as reported by Dambo, (1993) when compared with *P. aurita*. For all the periwinkle groups, this trend was maintained throughout the study: Station 3 > station 2 > station 1. It was also revealed that the monthly abundance and spatial distribution did not depend on the group of periwinkle as different periwinkle groups be it smooth or wrinkled followed the same pattern of abundance and distribution.

Recommendations

Based on the finding of this study, the following are recommended:

1. Discharge of untreated effluents into the river should be checked.
2. Indiscriminate deforestation of mangrove which are natural habitat for periwinkle should be avoided.
3. Anthropogenic activities such as sand mining and dredging which could disrupt the periwinkle habitats should be curtailed.
4. Taskforce should be initiated to monitor the activities of the inhabitants of the coastal region with this the rate of aquatic pollution will be reduced while enhancing biodiversity.

References

- Adebayo, B.C., Onilude, A.A. and Etuk, F.J. (2011). Studies on microbiological, proximate, mineral and heavy metal composition of fresh water snails from Niger Delta Creek in Nigeria. *Assumption Uni J Technol*, 14 (4), 290-298.
- Ajao, E.A. and Fagade, S.O. (1990). Production and population dynamics *Pachymelania aurita* Muller Arch. *Hydrobiol.* 120 (1), 97-109.
- Bob-Manuel, F.G. (2012). A preliminary study on the population estimation of the periwinkles *Tympanotonus fuscatus* (Linnaeus, 1758) and *Pachymelania aurita* (Muller) at the Rumuolumeni mangrove swamp creek, Niger Delta, Nigeria. *Agric. Biol. J. N. Am.*, 3(6), 265-270.
- Bouchet, P. and Pocher, J.P. (2005). Classification and nomenclature of gastropod families. *Malacologia: International Journal of malacology*, 47(1-2), 300-397.
- Dambo, W.B. (1993). Tolerance of the periwinkle *P. aurita* and *T. fuscatus* to refined oils. *Environ Pollution*. 79, 293-296.
- Egonmwan, R.I. (2007). The reproductive cycle of the mangrove Prosobranch, *Pachymelania fusca* in Lagos, Nigeria. *Pakistan journal of Biological Sciences*, 10: 649-653.
- Ekpo, E.A., George, U. U., Edet, M. (2015). Impacts of water pollution with heavy metal on the tissue of *Egeria radiata* (Bivalve: Tellinacea: Donacidae) (Lammark, 1804) obtained from Calabar River, Cross River State, Nigeria. *Nature and Science*, 13(8); 36-39
- Jamabo, N.A. and Alfred-Ockiya, J.F. (2000). *Tympanotonus fuscatus*-its potential and abundance in the mangrove swamps of the upper Bonny River, River State, Nigeria. 693-695.
- Saier, B. (2000). Age-dependent zonation of the periwinkle *Littorina littorea* (L.) in the Wadden Sea. *Helgol Mar Res.* 54, 224-229.
- Trussell, G. C., Ewanchuk, P.J., Bertness, M.D. and Silliman, B.R. (2004). Trophic cascades in rocky shore tide pools: distinguishing lethal and non-lethal effects. *Oecologia*. 139, 427-432.

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Ecological Impacts of Impoundment on Benthic Macroinvertebrates in Ivo River, Southeast Nigeria

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Abstract

Studies on ecological impact of impoundment on abundance and diversity of benthic macroinvertebrates (BMI) in Ivo River, Southeast. Nigeria was investigated from March to July 2018. A total of 169 individuals were collected representing 3 phyla and 6 genera. Three stations: Ivo River, Ishiagu (upstream), Ivo Dam, Mpu (impoundment), and Ivo River, Okpankwo (downstream) were selected. Ivo Dam recorded 20 individuals which were followed by Ivo River, Ishiagu and Ivo River, Okpankwo with 23 and 126 individuals respectively. Mollusca with 74.1% dominated the BMI phyla while Arthropoda (23.0%)> Annelida (2.4%). Shannon-Weiner diversity indices (H) showed Ivo Dam, Mpu (H=0.5004)> Ivo River, Okpankwo (H>0.4972)> Ivo River, Ishiagu (H= 0.3557). Evenness was in order of, Ivo Dam, Mpu (e = 0.8287)>Ivo River, Ishiagu (e = 0.4757)> Ivo River, Okpankwo (e=0.3288).The river had a low BMI abundance in the dam. The impoundment encouraged accumulation of wastes which were discharged downstream with severe effects on BMI composition, this paved way for the proliferation and abundance of Mollusca in Ivo River, Okpankwo which are pollution tolerant species. It is therefore vital to control the release of various wastes released into Ivo River and refresh the water in the impoundment by a routine discharge program.

Keywords: Bioindicator species, Water pollution, Sustainability, Tolerant species.

Introduction

Benthic macroinvertebrates (BMI) are organisms that are large enough to be seen with the naked eye, are associated with live in the bottom of lakes, ponds, streams, rivers, seas either burrowing or attached to various kinds of solid objects like boats, canoes, roots of plants, stones, vegetation, wood and they could be littoral or profundal (USA EPA, 2012). Some are larval form of flying insects such as mayflies, stone flies, caddisflies, midge flies etc. The most diverse group of fresh water BMI is insects; others are small animals that spend their entire life in streams such as mites and moist terrestrial environments such as freshwater snail (Oyediran and Ugwumba, 2019). According to Ogbeigbu and Oribgabor (2002) the knowledge of the structure of BMI community provides precise and local information on recent event which can be seen in their structure.

BMI are thus good indicators of water quality and hence could be affected by structural changes of the water ways (Ibrahim and Nafi'u, 2017).The increase in human population and its attendant pressure on the environment has subjected many water bodies to undergo structural changes through road/bridge construction, dredging, irrigation and dam construction. These activities always mostly affect the water flow as well as altering the ecological make-up of the immediate biotope and with significant ecological effects both on the temporal and spatial scales as well as affecting the natural connectivity of lotic ecosystems (Principe, 2010).There are many studies in various parts of the Nigeria on BMI of freshwater bodies. The emphasis in the previous works are more on the abundance and diversity of this group of BMI.

Ivo River has several tributaries, rivers and streams which flow from some parts of Abia, Enugu and Ebonyi States respectively (Asiegbu *et al.*, 2021). The river is however impounded to form a dam at Mpu, Enugu State for the purpose of irrigation, municipal water supply and hydroelectricity (Aseigbu *et al.*, 2019). The dam is a physical barrier which attenuate the rate of water flow with suspected other ecological changes of which the BMI are also players. Oyediran *et al.* (2017) documented an earlier studies of BMI in Ikwo River a tributary of Ivo River while Oyediran and Ugwumba (2019) also gave an account of the abundance and diversity of BMI in Lokpanta Reservoir, Ishiagu which is another water body in the recharging the river course. The authors recorded a low BMI taxa in their studies and this was ascribed to poor water quality occasioned by the intensive mining wastes discharge as well as run-offs of agrochemicals like pesticides, fertilizers and herbicides into river.

In Nigeria, the impact of dam on BMI have received little attention, the current study will investigate the impact of the construction of Ivo Dam, Mpu on the BMI community as the impoundment is suspected to affect the hydrology, water quality, biodiversity of the water body as well as the composition, migration and reproduction of aquatic organisms which could bring about a change in the community structure for the resident biota most especially the BMI.

Materials and methods

The sampling was in three stations for the purpose of the study.

Station 1: Ivo River at Federal College of Agriculture, Ishiagu, Ebonyi State on longitude 70 3353.54''E and latitude 50 54.47.16''N with elevation 16ft above sea level.

Station 2: Ivo Dam at Mpu, Enugu State Longitude 70 38'20.57'' E and latitude 50 57'31.64'' N with elevation 124ft above the sea level.

Station 3: Ivo River at Okpanku, Enugu State Longitude 70 38'34.45''E and latitude 50 59'07.89''N with elevation 131ft above the sea level.

BMI samples were collected at monthly intervals over a period of five months (March 2018 to July 2018) between 0700 hours and 1100 hours from the sampling stations, BMI fauna were collected by the use of 0.6m² Van Veem grab as described by Edward and Ugwumba (2010). Three replicate samples were collected at each sampled station. These were transported to the Department of Fisheries Technology Laboratory, Federal College of Agriculture, Ishiagu, Ebonyi State. In the laboratory, the sediments collected were washed through graduated sieves of 1mm, 2mm, and 3mm. The BMI collected from each station were then sorted into different taxonomic groups using a X10 magnifying lens. Each taxonomic group was placed in a specimen bottle containing 4% formalin and properly labeled. The BMIs were identified using manuals of Brown (1994); Victor and Ogbeibu (1985).

Data Analysis

Paleontological statistical software package for education (PAST 4.3) was used to evaluate diversity indices, taxa richness and species evenness of BMI in the sampling stations. MS Excel 2013 was used for graphical representations.

Results and Discussion

The results of the study showed that six BMI genera from three phyla: Arthropoda, Mollusca and Annelida. Arthropoda were represented by one class insecta, represented by two orders of Diptera and Ephemeroptera. The Mollusca were of two classes of gastropoda and bivalvia while Annelida were represented by class clitellata, order arhyncyobdellida. Spatial abundance as shown in Table 1, Ivo Dam recorded 20 individuals which were followed by Ivo River upstream and Ivo River downstream with 23 and 126 individuals respectively.

BMI of the three stations was dominated by the Mollusca. They constituted 74.1% of the total number of BMI. Amongst them, *Melanoides tuberculata* had the highest percentage composition (65%) followed by *Diplodonta diaphana* (7.1%). The least abundant mollusca was *Bulinus globossus* which made up 2.4% of the total number of BMI. Amongst the Arthropods, the chironomid was the most dominant which made up 22.4% of the total BMI abundance by number. The Annelida was only represented by *Hirudo medicinalis* which accounted for 2.4% of the total population as shown in Table 1. Ivo River upstream recorded 21 arthropoda and 2 mollusca with no occurrence of annelida, Ivo Dam had 16 Arthropoda and 4 Annelida with no record of mollusca. Ivo River downstream was with 2 arthropoda and 124 mollusca. Taxa richness with Shannon-Wiener index (H) for diversity is shown in Table 2 which was generally low in Ivo River upstream (H=0.3557) and Ivo River downstream (H=0.4972), while a higher value was recorded in Ivo Dam (H=0.5004) (impoundment). Ivo River upstream (e=0.4757) and Ivo River downstream (e=0.3288) had similar values of evenness and a higher value in Ivo Dam (e=0.8247).

BMI composition of Ivo River had a low taxa number. This is not surprising in tropical water bodies for instance, Ikwo River, Ishiagu, Ebonyi State a tributary of Ivo River also recorded a low taxon (Oyediran *et al.*, 2017). Similar observations were reported by Edward and Ugwumba (2010) in Egbe Reservoir, Ondo State, Nigeria. Victor and Dickson (1985) and Umeozor (1996) also recorded low taxa number and diversity in Ikpoba River. The low abundance could be ascribed to some physico-chemical conditions of water like fast flow, fluctuating pH, low dissolved oxygen and low conductivity as well as high metallic loading as reported by Ezekwe *et al* (2013),

Oyediran and Ugwumba (2019). These factors probably caused disruption of life cycle, reproductive cycle, food chain and migrations or imposed physiological stress on even the tolerant BMI (Ibezute and Asobor, 2016).

BMI were probably severely affected by physical disturbances associated with the construction of the impoundment which led to increased runoff and erosion from the deforested landscape (Rybak and Sadlek, 2012). Chironomids were classed as lentic BMI taxa by Poulos *et al.* (2019), however their cosmopolitan nature in the river which accounted for the second most abundant in the overall population of BMI is not far-fetched, they are known to adapt to all kinds of environments including polluted waters (Victor and Ogbiebu, 1991, Oyediran and Ugwumba, 2019) and they can quickly replace other invertebrate taxa in water bodies affected by human activities. This survival strategy is based on their ability to leave on very low oxygen concentration. However, there were variations in the densities of *Chironomus spp* encountered in all the stations, this could be connected to the difference substrate compositions which created diverse microhabitats with nutrient variability.

The relative abundance of *Hirudo medicinalis* an Annelida in Ivo Dam (station 2) was probably connected to a change from a lotic habitat to a lentic one (Rybak And Sadlek, 2012), since running water from Ivo River upstream (Station 1) possibly transported organic deposits into Ivo Dam (Station 2) this could have formed a homogeneous substratum in the bottom. An earlier observation was reported by Gao *et al.* (2013) that impoundment supports organic matter decomposition. This substratum is known to support the colonization of Chironomidae and enhances their development (Ibezute and Asobor, 2016).

Generally, dams are settling basins, and they increase water transparency by retaining fine sediments (Principe, 2010). This process have probably incorporated most phosphorus and nitrogen and released better quality water in Ivo River downstream at Okpankwu which resulted in many taxa and abundance of BMI. The high occurrence of the Mollusca and the absence other invertebrates in Ivo downstream (Station 3) could be a pointer that the station was possibly polluted because of the high concentration of both organic and inorganic wastes from stations upstream as earlier work of Ezekwe *et al.* (2013) implicated the mining discharge of a lead /zinc mining company in Ihietutu, Ishiagu which is not far from the study area. In the same vein, the station was surrounded with cassava and rice farms with suspected application of fertilizers which could have been washed down into the river with increase in organic loads. The presence of *Bulinus globosus* in Ivo River upstream and downstream could be attributed to their distribution in flowing water bodies. The Mollusca group recorded in Ivo River downstream (Station 3) are all pollution tolerant species because of their ability to withstand water quality perturbation. On the other hand, the total absence of chironomids in Ivo River downstream could be ascribed to their preference to lentic water (Poulos *et al.*, 2019). The scarcity of other BMI in the station could be linked to the findings of Hall *et al.* (2016) that an impoverished BMI fauna community could be associated with the physico-chemical and geochemical nature of the sediment (fertility), water depth, sediment type, water current, sediment erosion due to intensive farming and clearing of ground cover which cause silting and adverse effect on the BMI community.

Table1: Relative Abundance of Benthic macroinvertebrates in Ivo River

	Station 1	Station 2	Station 3	Total	% Prevalence
Arthropoda					
<i>Chironomus spp</i>	21	16	1	38	22.4
<i>Ephemerella excrucians</i>	0	0	1	1	0.6
Total	21	16	2	39	23.0
Mollusca					
<i>Bulinus globosus</i>	1	0	3	4	2.4
<i>Melanoides tuberculata</i>	0	0	110	110	65
<i>Diplodonta diaphana</i>	1	0	11	12	7.1
Total	2	0	124	126	74.6
Annelida					
<i>Hirudo medicinalis</i>	0	4	0	4	2.4
Total	0	4	0	4	2.4
Grand total	23	20	126	169	100

Table 2 Benthic macro-invertebrates diversity indices in the different sampling stations of the Ivo River

	Ivo River upstream	Ivo Dam	Ivo River downstream

Number of taxa	3	2	5
Number of individuals	23	20	126
Shannon-Weiner index(H)	0.3557	0.5004	0.4972
Evenness (e)	0.4757	0.8287	0.3288

The low species diversity could be connected to some physical properties of the water body e.g. fast flow, and other chemical factors that were initially investigated as been poor for both human and biodiversity in the river course by Asiegbo *et al.* 2012 (2019). These factors when combined may severely disrupt life cycle, food chain and migrations or imposed physiological stress on even the tolerant BMI (Adakole and Annune, 2003). However, Yakub and Ugwumba (2009)) reported that the bigger the size of a lotic water body, the poorer the BMI richness. In the case of Ivo River, the low taxa number observed could in addition be due to factors other than physico-chemical conditions of the water such as habitat preference, resource partitioning, and food availability. For instance, Edward and Ugwumba (2011) had reported that diversity tends to be low in physically controlled systems such as ponds and impoundments. This could be the case here in the Ivo River because of the construction which led to the physical restructuring and loss of both the original riparian and aquatic habitats. The low values of diversity indices may indicate negative impacts of impoundment on BMI communities. Impoundment of water bodies have been reported to have profound effects on the composition of the resident organisms in water bodies (Ogbeibu and Oribhabor, 2002). The reduced values may also indicate pollution stress which is further confirmed by the low evenness (e) values of most of the sampled stations. The ecological structure of BMI communities in Ivo River was more stagnophil species preferring stagnant water and less reophil species.

The construction of the impoundment created a change in water flow from a fluivate to stagnant habitat. The study area is marked with various anthropogenic activities and the river is a major point for waste discharge. This gave room for a continuous accelerated accumulation of wastes in the water body especially in Ivo Dam (station 2). Thus, encumbering BMI abundance and diversity, hence the construction of the impoundment in Ivo River created an accumulation of wastes with a fragile habitat that could not support a flourishing BMI fauna. It is therefore recommended that there should be strict measures against the indiscriminate release of wastes into the river. The management of Ivo Dam should engage in periodical discharge of water from Station 2 (impoundment) in order to refresh the system. The research has identified impacts of impoundment on BMI communities using data that were collected for a few months, and thus, extrapolation to longer time frame is likely to be confounded by temporal variation in environmental drivers and biota phenology. It is therefore suggested that future research should be carried out over longer time.

References

- Adakole, J.A. and Annune, P.A. (2003). Benthic macroinvertebrates as indicators of environmental quality of an urban stream, Zaria, Northern Nigeria. *Journal of Aquatic Science* 18: 85-92.
- Asiegbo, V. O., Oyediran, A.G. and Ezekwe, I. C. (2021) Conservation status of fish fauna in Ivo River Basin Southeastern Nigeria. *Acta Scientific Microbiology Journal* 4 (7): 3-7.
- Asiegbo, V. O., Oyediran, A.G. and Ezekwe, I. C. (2019) Preliminary investigation of the Distribution and relative abundance of plankton and fish species in Ivo River Basin Southeastern Nigeria. *Acta Scientific Microbiology Journal* 2(4):8-15
- Brown, D. S. 1994. Freshwater Snails of Africa and their Medical Importance. 2nd ed. London: *Taylor and Francis*. pp45-234.
- Edward J. B and Ugwumba, A. A. A. (2010) Macroinvertebrate Fauna of a Tropical Southern Reservoir, Ekiti State, Nigeria. *Continental Journal of Biological Sciences* 4 (1): 30 – 40.
- Gao, Y., Wang, B., Liu, X., Wang, Y., Zhang1, J., Jiang1, Y and Wang, F. (2013). Impacts of river impoundment on the riverine water chemistry composition and their response to chemical weathering rate. *Front. Earth Science* 32: 56-62.
- Hall, L.W., Jr.; Anderson, R.D.; Killen, W.D. (2016) Spatiotemporal trends analysis of benthic communities and physical habitat during non-severe drought and severe-drought years in a residential creek in California, USA. *Fish Game* 102: 55–70.
- Ibrahim, S. and Nafi'u, S.A (2017) Macroinvertebrates as Indicators of Water Quality in Thomas Dam, Dambatta, Kano State, Nigeria. *UMYU Journal of Microbiology Research* 2 (1):62-71
- Ibezute, A and Asobor, G (2016) Ecological Assessment of Brewery Effluent Impact on the Macrobenthic Invertebrates of Ikpoba River, Edo State, Nigeria. *International Journal of Ecosystem* 6(3): 47-54

- Ogbeibu, A. E. and Oribhabor, B. J. (2002). Ecological impact of river impoundment using benthic macro invertebrates as indicators. *Water Research* 36: 2427 – 2436.
- Oyediran, A. G, Ebeniro, L. A, Ayodele ,O. P, Olaoti, K. S and Nwoga, P (2017) Seasonality, Abundance and Distribution of benthic macroinvertebrates as bio-indicators of Water quality in Ikwo River, Ishiagu, South-Eastern Nigeria. *Journal of Faunal and Biological Sciences* 4(2): 43-46
- Oyediran, A. G. and Ugwumba A. A. A. (2019) Impact of mining discharge on spatial abundance and distribution of benthic macroinvertebrates in Lokpanta Reservoir, Ishiagu, Ebonyi State, Nigeria. In Ude, E.F.(Ed), *Proceeding of the 34th Annual Conference of Fisheries Society of Nigeria (FISON)* (pp 390-392). Abakaliki, Nigeria: FISON.
- Poulos, H. M., Miller K. E., Heinemann, R., Kraczkowski, M. L, Whelche, A. W and Chernob, B. (2019) Dam Removal Effects on Benthic Macroinvertebrate Dynamics: A New England Stream Case Study (Connecticut, USA). *Sustainability* 11: 2875-2900.
- Principe, R. E. (2010) Ecological effects of small dams on benthic macroinvertebrate communities of mountain streams (Cordoba, Argentina). *International Journal Limnological* 46: 77–91.
- Rybak, J and Sadleir, W (2012) Ecological Impact of a Dam on Benthic Macroinvertebrate in Montane Rivers of lower Silesia. *Environment protection Engineering* 36 (2): 143-151
- US Environmental Protection Agency (USEPA). (2012) National aquatic resource surveys. http://water.epa.gov/type/watersheds/monitoring/aquaticsurvey_index.cfm. Accessed: 17 April, 2018.
- Victor, R. and Ogbeibu, A. E. 1985. Macrobenthic invertebrates of a stream flowing through farmland in Southern Nigeria. *Environmental Pollution series* 39: 333-347.
- Yakub AS, Ugwumba AAA. (2009).A study on the macroinvertebrate fauna of lower Ogun River at Ishasi South west Nigeria. *The Zoologist* 7:65-74.

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Dry Season Assessment of Phytoplankton in Badagry Creek**Elegbeleye, O. W.¹, Yusuf, W. A.², Adeyemo, D. A.¹, Ekpeni, N. M.³**¹Department of Marine Sciences, University of Lagos Akoka, Lagos, Nigeria ²Department of Fisheries Resources, Nigerian Institute for Oceanography and Marine Research (NIOMR)³Department of Geography, University of Lagos Akoka, Lagos, Nigeria.

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Abstract

Phytoplankton composition, abundance and physicochemical parameters at the Badagry Creek, Lagos were studied for a period of six months (November, 2018-April, 2019). The physicochemical conditions varied with Air temperature (29.2°C-32.0 °C), Water temperature (29.0°C-31.0 °C), Transparency (74cm – 106.75cm), Salinity (9.8‰– 25.00 ‰), Rainfall (0mm – 222.9mm), pH (6.90 – 7.65), Dissolved Oxygen (5.40mg/L – 6.80mg/L), Nitrate (5.2– 10.3), Phosphate (0.37 – 7.65), Biochemical oxygen demand (1.00 mg/L – 2.00 mg/L), Chemical oxygen demand (8.00 mg/L – 9.00 mg/L), Total dissolved solid (10500mg/L – 28500mg/L). A total of 32 phytoplankton taxa belonging to four algal divisions were identified throughout the study period. The division Bacillariophyta accounted for 74.29% of the forms present, Cyanophyta accounted for 17.14%, Chlorophyta accounted for 5.71% and Pyrrophyta accounted for 2.86%. The species richness (d) was higher in April with a value of 7.34. The highest number of phytoplankton species was recorded in the month of April with a total of 152 species while the lowest number of phytoplankton species was recorded in February with a total of 44 species. Some notable genera recorded were *Nitzschia*, *Coscinodiscus*, *Oscillatoria*, *Biddulphia*, *Thalassionema*, *Syndera* and *Closterium* in the descending order of relative abundance. In conclusion, Carlson's trophic state index shows that the study site as at the period of study was mesotrophic in nature. The water chemistry characteristics showed monthly variations that influenced the diversity and abundance of phytoplankton recorded.

Keywords: Phytoplankton, Physicochemical parameters, Creek.**Introduction**

Phytoplankton are free-floating microscopic plant that contain chlorophyll and grow by photosynthesis and lack roots, stems and leaves. They are the foundation of the aquatic food web, the primary producers, feeding everything from microscopic, animal-like zooplankton to multi-ton whales. Growth and photosynthesis are closely related, each being a function of the utilization of light and nutrients. Dugdale and Wilkerson (1986) described the growth of an algal population as being proportional to the effect of light on photosynthesis (Ryther, 1956), the concentration of nutrients, and the maximum specific growth rate. Pollutant can affect the relation between growth rate and each of these variables. For example, if an industrial effluent is coloured or contains suspended solids, light may be filtered or absorbed by it, resulting in a reduced growth rate. Badagry creek is under consistent and sometimes severe pressure from diverse forms of human activities emanating from the surroundings. The creek is usually very busy. Cargo ships ply the creek to and from the Tin Can Island and Apapa ports, oil tankers ply the creek to and from the various oil jetties on the creek and ferries take people to and from the Mile 2 jetty. This study investigated dry season assessment of phytoplankton in badagry creek, lagos.

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Materials and Methods

Study area

Badagry Creek is a creek that flows from Benin Republic into Commodore Channel in Lagos. It is also known as Porto Novo Creek. It has a length of 4.62 kilometers. Badagry Creek lies within Latitudes 6° 22' N and 6° 42' N and Longitudes 2°42' E and 3°42' E (Figure 1). Badagry Creek is bordered by Apapa, Ajegunle, Kirikiri, Mile 2, Amuwo Odofin, Satellite Town, Navy Town, Nigerian Navy Air Station, Ojo, Badagry, etc. There are many islands on the creek, including Tin Can Island and Snake Island. This aquatic ecosystem is habitat to a variety of biota which include the plankton, nekton and benthos in a complex trophic interrelationship.

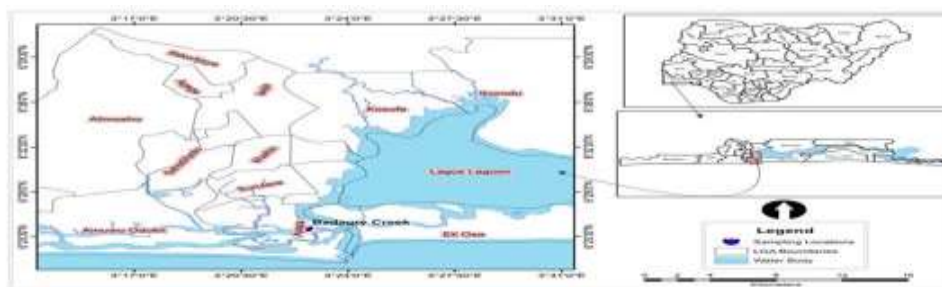


Figure 1. Map of Study Study Area, Badagry Creek

Water Collection

Water samples were collected for water chemistry analysis in well labeled 75cl plastic containers with screw cap at the surface of the water body. The sample bottles were screwed tight, kept upright and transported to the laboratory for further analysis.

Plankton Collection

Plankton samples were collected using a plankton net of 55 µm mesh size, hauled horizontally on a motorized boat and towed at low speed (<4 knots) for five minutes. The collected samples were concentrated and stored in 500 ml plastic jars with screw caps, and preserved in 4% unbuffered formalin.

Physicochemical analyses Air and surface water temperatures (°C) were measured with a mercury-in-glass thermometer; salinity was determined using saline test meter (Hanna Instrument HI 98203; pH was measured in the laboratory using the electrometric method using the Cole Parmer Test; dissolved oxygen (mg/L) was estimated by the Titrimetric method using the Azide Modification procedure 4500°C (APHA, 2005).

Statistical analysis

Data generated were analyzed using descriptive and inferential statistics such as Principal Components Analysis (PCA), Canonical Correspondence Analysis (CCA), Nutrient stoichiometry and Pearson's correlation coefficient.

Results

Physicochemical parameters

The physico-chemical properties of the water observed lowest surface water temperature in January and April (29.0 °C) and highest with 31.0 °C in March. The physicochemical conditions varied with Air temperature (29.2°C-32.0 °C), Transparency (74cm – 106.75cm), Salinity (9.8‰– 25.00 ‰), Rainfall (0mm – 222.9mm), pH (6.90 – 7.65), Dissolved Oxygen (5.40mg/L – 6.80mg/L), Nitrate (5.2 – 10.3 mg/L), Phosphate (0.37 – 7.65 mg/L), Biochemical oxygen demand (1.00 mg/L – 2.00 mg/L), Chemical oxygen demand (8.00 mg/L – 9.00 mg/L), Total dissolved solid (10500mg/L – 28500mg/L).

Phytoplankton

The phytoplankton diversity was presented by two (4) Divisions namely: Bacillariophyta, Chlorophyta, Pyrrophyta and Cyanophyta. The division Bacillariophyta accounted for 74.29% of the forms present, Cyanophyta accounted

for 17.14%, Chlorophyta accounted for 5.71% and Pyrrophyta accounted for 2.86%.

Discussion

Phytoplankton data from this investigation reveals reduction in abundance and diversity of species compared with earlier works (Nwankwo, 1996; Onyema *et al.*, 2007). This variation could be attributed to human activities such as sporadic dredging, sand mining, oil wastes, industrial effluents discharge, domestic water sewage discharges among others at the Badagry creek area. The phytoplankton of the Badagry creek, Lagos was numerically dominated by diatoms followed by the cyanophytes, Chlorophytes and Pyrrophyta in this order during the dry season. This finding is also similar to earlier reported by Nwankwo, (1996 and 2004).

Air temperature was higher in months with low precipitation for the station. These observations may be due to increased insolation due to lower cloud cover and cessation of rainfall as previously reported by Nwankwo (1996) and Onyema *et al.*, (2007). Transparency and Rainfall. In months with low precipitation, TSS was low possibly due to low flood water into the creek. The pH of this study ranged between 6.90 – 7.65 in November and February respectively. A pH value of greater than 7 is basic. According to Abowei (2010), pH higher than 7 but lower than 8.5 is ideal for biological productivity. The Biochemical oxygen demand observed for the station ranged between 1.00 and 2.00mg/L possibly indicating a moderately polluted environment which could be associated with the discharge of oil, solid wastes and household wastes. The high availability of nutrients (phosphate, silicate and sulphate) may have encouraged the growth and abundance of phytoplankton as indicated by Chlorophyll *a* levels. The high levels of

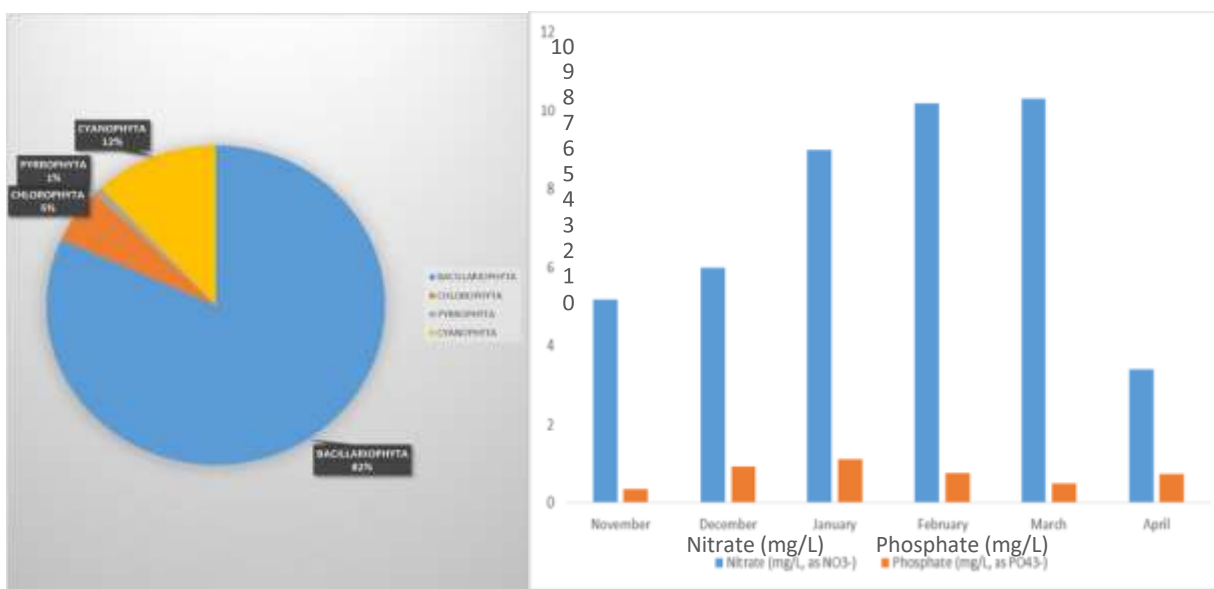


Figure 2. The relative abundance of phytoplankton and nutrient stoichiometry ratio representation of nitrate and phosphate at Badagry Creek, Lagos Lagoon between November 2018 and April 2019

Conclusion

The presence of organic pollution in Badagry creek can be linked to cultural eutrophication due to sewage and as shown by the water analysis. The Dissolved oxygen in the creek is below standard lake levels and is not enough to sustain a diverse community. However, sand mining activity should be discouraged in the study site in order to enhance its phytoplankton biodiversity.

References

- Abowei, J.F.N. (2010). Salinity, Dissolved Oxygen, pH and Surface Water Temperature Conditions in Nkoro River, Niger Delta, Nigeria. *Advance Journal of Food Science and Technology*, 2:36-40
- APHA. (American Public Health Association). (2002), in: Standard Methods for the Examination of Water and Waste Water, 22nd ed., APHA, New York. 1475pp ISBN: 9780875532875.
- Dugdale, R. C. and EP Wilkerson. (1992). Nutrient limitation of new production in these a, p,107-122. ZnI?G.Falkowski and A.D. Woodhead [eds.], Primary productivity and biogeochemical cycles in these a Plenum.
- Nwankwo, D.I. (2004). The Microalgae: Our indispensable allies in aquatic monitoring and biodiversity
- Nwankwo, D.I. (1996). Phytoplankton diversity and succession in Lagos lagoon, Nigeria. *Archiv Fur Hydrobiologie*. 135(4): 529-542.
- Onyema, I.C. (2007). The Phytoplankton Composition, Abundance and Temporal Variation of a Polluted Creek in Lagos, Nigeria. *Turkish Journal of Fisheries and Aquatic Sciences*. 7: 89-96.
- Onyema, I.C., Okpara, C. U., Ogbabor, C. I. Otudeko, O. & Nwankwo, D. I. (2007). Comparative studies of the water chemistry characteristics and temporal plankton variations at two polluted sites along the Lagos lagoon, Nigeria. Ecology, *Environment and conservation*.13: 1 – 12
- Ryther, J.H. (1956). Photosynthesis in the ocean as a function of light intensity. *Limnol. Oceanogr*.1:61-70.

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Length-Weight Relationships and Condition Factor of *Heterotisniloticus* and *Clariasgariiepinus* from Lake Geriyo, Adamawa State

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Abstract

The length-weight relationships and condition factors of *Heterotisniloticus* and *Oreochromisniloticus* from Lake Geriyo were studied. 308 samples of *H. niloticus* and 342 samples of *O. niloticus* were collected from fishermen catches at the landing site. The results from the study showed a negative allometric growth pattern in both species studied with LWR equations for *H. niloticus* established; $\log W = 1.971 \log TL - 0.5471$, $R^2 = 0.8429$ and $\log W = 2.1151 \log TL - 0.8898$, $R^2 = 0.9064$ for *O. niloticus*. The coefficients of determination, R^2 indicate strong relationships between the length and the weight in both species. The mean condition factor showed that the species were in good condition. This information will be very useful for the development of management strategies of the fish.

Keywords: length-weight relationship, condition factor, *Heterotisniloticus*, *Oreochromisniloticus*, Lake Geriyo

Introduction

Length weight relationship (LWR) is a useful tool that has been widely applied to reveal the pattern of growth in aquatic animals (Getso, 2017; Lauratet *et al.*, 2019; TaheriMirghaedet *et al.*, 2021). In the field of fishery biology, investigation of the LWR is undertaken to achieve two major purposes; firstly, to offer mathematical relationship as a means of conversion between length and weight, and secondly to estimate the condition factor or coefficient of condition (Gupta and Gupta, 2006).

The condition factor, which is an index reflecting interaction between biotic and abiotic factors in the physiological conditions of fishes may vary among fish species in different locations (Blackwell *et al.*, 2000). In fisheries science, the condition factor (K) is used to compare the "condition", i.e., fatness or wellbeing of fish (Getso, *et al.*, 2017; Lauratet *et al.*, 2019). This is based on the hypothesis that heavier fish of a particular length are in a better physiological condition. Condition factor also a useful index for monitoring feeding intensity, age, and growth rates in fish (Ujjaniaet *al.*, 2012).

Heterotisniloticus (African bony-tongue) is one of the accepted food fish species in Nigeria inland waters. It may be due to the firmness in the flesh texture and the large size. This species is widely distributed in rivers, creeks and freshwater lakes of Western and Central Africa, and it has become popular in fish farming in Nigeria today due to its fast growth rate, ability to withstand stress, and survive in water with low oxygen content, which has endeared it to many fish farmers (Ikot, *et al.*, 2020). *Oreochromisniloticus* (Nile tilapia) is a common fish species in the tropics and one of the world's most important food fishes. Owing to its hardy nature, and its wide range of trophic and ecological adaptations, it has been widely introduced for aquaculture, augmentation of capture fisheries and sport fishing (Raj *et al.*, 2016; Keyombeet *al.*, 2017). This study was carried out with the aim of assessing the growth pattern of the two species of fish with the view of bridging the information gap on the condition of fish inhabiting the Lake.

Materials and Methods

Study area: The study was carried out in Lake Geriyo (Fig. 1). It is a flood plain lake, located at the outskirts of Jimeta metropolis Adamawa state on the North-East Nigeria. It lies between longitude 12°25'E and latitude 9°8'N. It is a shallow water body with a mean depth of about 2 meters and the mean annual rainfall is between 900 and 1100 mm with the rainy season ranging from 150 to 160 days, usually from May to October. Temperature ranges from 20°C in December to January and intense heat with temperatures of 30°C to 42°C in March to April. It experiences some influx of waters from flood during rainy season and overflows from river Benue which serves as a major water source to the lake.

Sample Collection: Fish samples were collected from fishermen catches at the landing site. A total of three hundred and eight (308) samples of *H.niloticus* and three hundred and fourty two (342) samples of *O.niloticus* were collected. Fish samples were transferred into an ice box packed with ice and immediately transported to the laboratory for further analyses.

Laboratory studies: In the laboratory, standard length and total length were measured and recorded using measuring board graduated in centimeters (cm) and body weight was measured in grams (g) using an electronic digital balance (Simon TH-5000).



Fig 1: Map of the study area.

Data analysis: The parameter of length-weight relationship of sampled fish species were evaluated using the equation $W = aL^b$ (Le Cren, 1951), where W = body weight in g, L = total length in cm, a = constant and b = relative growth coefficient. Logarithmic transformation of the formula ($W = aL^b$) into $\log W = \log a + b \log TL$ was done, while each value of 'a' and 'b' was determined empirically employing common statistics. Fulton ($K = 100WL^{-3}$) condition factor was calculated for males and females for the different months; where, W = observed body weight (g), L = total length (cm), (Amin, 2001; Zoricaet al., 2006). All statistical analyses were performed using Microsoft Excel, MINITAB version 17 and SPSS version 22 statistics software.

Results

Length-weight relationship: Total length ranged from 19.30cm to 41.70cm (30.06 ± 0.24) in *H. niloticus* and 17.40cm to 54.50cm (28.29 ± 0.30) in *O. niloticus*. Body weight ranged from 90.30g - 441.40g (238.24 ± 3.89) and 39.41g - 468.11g (159.81 ± 4.03) in *H. niloticus* and *O. niloticus* respectively as shown in Table 1. The LWRs indicate a negative allometric growth pattern for both *H. niloticus* and *O. niloticus* as shown in Figs. 2a & 2b. The length-weight relationship equations for *H. niloticus* could establish as; $\log W = 1.971 \log TL - 0.5471$, $R^2 = 0.8429$ and $\log W = 2.1151 \log TL - 0.8898$, $R^2 = 0.9064$ for *O. niloticus*.

Table 1: Length and weight data of *H. niloticus* and *O. niloticus* from Lake Geriyo.

	<i>H.niloticus</i> (n=308)		<i>O.niloticus</i> (n=342)	
	Range	Mean $\pm$ SE	Range	Mean $\pm$ SE
Total Length (cm)	19.30 – 41.70	30.06 ± 0.24	17.40 – 54.50	28.29 ± 0.30
Body Weight (g)	90.30 - 441.40	238.24 ± 3.89	39.41 – 468.11	159.81 ± 4.03

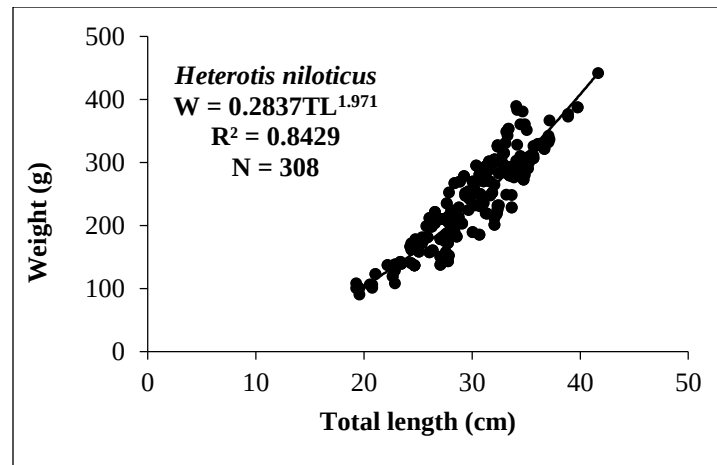


Fig 2a: Length-weight relationship for *H. niloticus*.

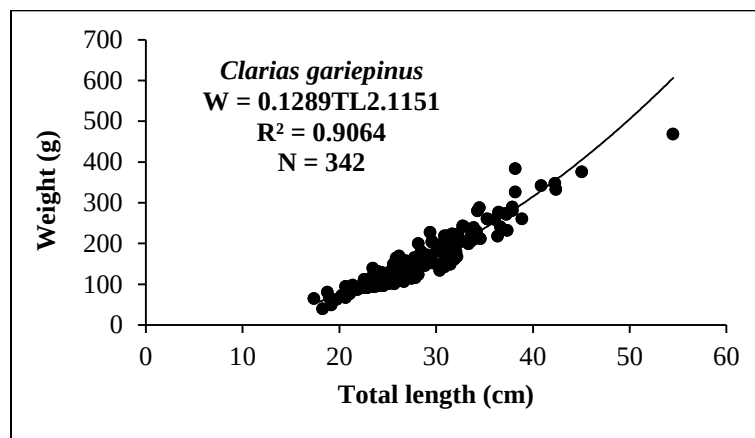


Fig 2b: Length-weight relationship for *O. niloticus*.

The condition factors of *H. niloticus* and *O. niloticus* in study area are presented in Table 2. From the results, the condition factor ranged from 0.0187 to 1.3069 ($0.1.0007 \pm 0.0144$) in *H. niloticus* and 0.6533 to 1.3793 (1.0087 ± 0.134) in *O. niloticus*. However, there was no significant difference in the condition factor among the two species studied ($P > 0.05$).

Table 2: Length and weight data of *H. niloticus* and *O. niloticus* from Lake Geriyo.

	N	Mean K-value	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
<i>H. niloticus</i>	308	1.0007 ^a	0.144	0.0082	0.9846	1.0168	0.0187	1.3069
<i>O. niloticus</i>	342	1.0087 ^a	0.134	0.0074	0.9941	1.0233	0.6533	1.3793

Note: Means with the same letter superscript are not significantly different ($P > 0.05$)

Discussion

The significance of the study is to examine the condition of the two major fish species in Lake Geriyo and provide information on the species that will help in management and maintenance of biological equilibrium of the lake. In fisheries assessment, length-weight relationship provides useful information on the growth pattern of a particular stock. From this study, the regression coefficients of LWR of both *H. niloticus* and *O. niloticus* indicate a negative allometric growth pattern ' $b < 3$ ' ($b = 1.971$ and 2.1151) existed within the fishes. This implies that the fishes become thinner with increase in length animals (Getso, *et al.*, 2017; Lauratet *al.*, 2019; TaheriMirghaedet *al.*, 2021). The

negative allometric growth pattern is similar to what was observed for *O. niloticus* by Getso, *et al.* (2017) in Wudil River, Kano Nigeria and Lauratet *al.* (2019) in lower River Benue, Nigeria.

Condition factor (K) is often used to describe the “well-being or condition of fatness of the fish”. This is based on the assumption that fatness in relation to a particular length implies better physiological conditions in the fish (Lauratet *al.*, 2019). It usually gives information about the physiological state of the fish in relation to some environmental changes (Getso, *et al.*, 2017). In this study, the Fulton’s condition factor (K) for *H. niloticus* ranged from 0.018 to 1.3069 with a mean (K) of 1.0007 and that of *O. niloticus* ranged from 0.6533 to 1.3793 with a mean of 1.0087 indicating that the population is in good condition. Generally, a condition factor close to, or above 1 is desirable (Keyombe *et al.*, 2017; Lauratet *al.*, 2019). The condition factor of *O. niloticus* (1.48 female, 1.32 male) and *C. citrhatus* (1.57 female, 1.34 male) were low comparable to the values reported Lauratet *al.*, 2019 for *O. niloticus*. According to TaheriMirghaedi *et al.* (2021), condition factor of fish are affected by many of the factors previously highlighted earlier for the variations in the values of “b” in this study (i.e. strain, species, stress, sexes, availability of feeds, water quality etc.). Hence, this could justify the differences between the observations of the present study.

Conclusion

In conclusion, the study of length-weight relationship and condition factor of a fish gives detailed information on the growth pattern of a species; this will help to know the state of the fish stock as well as for proper fishery management and sustainable exploitation of stocks.

References

- Amin, S. M. N., (2001). Studies on age and growth, VPA analysis and relative condition factor of *Harpodon nehereus* (Ham-Buch) from the neritic water of Bangladesh. *Online Journal of Biological Sciences*, 1, 192-194.
- Blackwel B.G., Brown M.L., Willis D.W. (2000). Relative weight (Wr) status and current use in fisheries assessment and management. *Reviews in Fisheries Science*, 8, 1-44.
- Getso, B. U., Abdullahi, J. M. and Yola, I. A. (2017). Length-weight relationship and condition factor of *Clarias gariepinus* and *Oreochromis niloticus* of Wudil River, Kano, Nigeria. *Agro-Science*, 16(1), 1-4.
- Gupta, S. K. and Gupta, P. C. (2006). *General and Applied Ichthyology: (Fish and Fisheries)* (First ed.). New Delhi, India: S. Chand and Company Ltd.
- Ikot, N. U., Ekanem, S. B. and Eyo, V. O. (2020). Aspects of reproductive biology and abundance of African bonytongue (*Heterotis niloticus*) in great Kwa river, Nigeria. *Open Journal of Bioscience Research*, 1(1), 55-65.
- Keyombe, J. L., Malala, J. O., Waithaka, E., Lewo, R. M. and Obwanga, B. O. (2017). Seasonal changes in length-weight relationship and condition factor of Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758) (Cichlidae) in Lake Naivasha, Kenya. *International Journal of Aquatic Biology*, 5(1), 7-11.
- Le Cren, E. D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *The Journal of Animal Ecology*, 201-219.
- Raj, S., Kumar, A. B. and Abraham, K. M. (2016). Length-weight and length-length relationship of invasive alien species, *Oreochromis niloticus* from lentic habitats of Palakkad district, Kerala. *Journal of Aquatic Biology & Fisheries*, 4, 141-146.
- Taheri Mirghaedi, A., Ghodrati Shojaei, M., Taghavi Motlagh, S. A., Mashhadi Farahani, M. and Weight, M. (2021). Length-weight and length-length relationships of eight fish species from Hara Biosphere Reserve; a mangrove swamp in the Persian Gulf. *Iranian Journal of Fisheries Sciences*, 20(1), 292-297.
- Ujjania, N. C., Kohli, M. P. S., and Sharma, L. L. (2012). Length-weight relationship and condition factors of Indian major carps (*C. catla*, *L. rohita* and *C. mrigala*) in Mahi Bajaj Sagar, India. *Research Journal of Biology*, 2(1), 30-36.
- Zorica, B., Sinovčić, G., Pallaoro, A., and Čikeš Keč, V. (2006). Reproductive biology and length-weight relationship of painted comber, *Serranus scriba* (Linnaeus, 1758), in the Trogir Bay area (middle-eastern Adriatic). *Journal of Applied Ichthyology*, 22(4), 260-263.

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Evaluation of Length-weight Relationship and Condition Factor of *Oreochromis niloticus* and *Auchenoglanis biscutatus* of Kiri Reservoir, Adamawa State, Nigeria

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Abstract

A study on Evaluation of Length-weight Relationship and Condition Factor of *Oreochromis niloticus* and *Auchenoglanis biscutatus* of Kiri reservoir was conducted over a period of eighteen months (September, 2017-February, 2019) using standard methods. The 'b' value of *Oreochromis niloticus* for 'b' value for the length-weight regression analyses of *O. niloticus* obtained from this study were sites A (1.2618), site B (1.3418) and site C (1.0757), all shown allometric growth. The 'b' values for *Auchenoglanis biscutatus* at site A (2.3009), site B (2.1489) and site C (2.0677), sites A, B, C shown allometric growth. This shows that increase in length was not equal to increase in weight of the two species of fish. This might be as a result of agricultural activities, open defecation, waste disposal into the water and domestic abuse of the water. The results of the monthly mean condition factor which recorded 2.773 - 5.136 and 1.086 - 2.266 for the *Oreochromis niloticus* and *Auchenoglanis biscutatus* are an indication that the fishes were in stable condition throughout the period of this study.

Keywords: Condition Factor, Kiri, Length-weight, Reservoir, *O. niloticus*, *A. biscutatus*

Introduction

Length-weight and length-length relationships are used extensively in fishery research and management (Wang *et al.*, 2012). According to Akinsanya *et al.* (2007), the emanating need to culture fishes for protein consumption for the rapidly growing population in Nigeria has made it necessary to intensify studies on the length frequency of the African freshwater fishes. It is equally necessary to provide and increase the knowledge of the stock available. The length-weight relationship is one of the standard methods that yield valid biological information. It establishes the mathematical relationship between the two variables (length and weight) so that the unknown variable can be readily computed from the known variable. Length and weight data are essential for estimating growth rates, age structure (Kohler *et al.*, 1995), for calculating the standing stocks biomass (Martin-Smith, 1996), condition indices (Safran, 1992) and several other aspects of fish population dynamics (Morato *et al.*, 2001). Knowledge of length-weight relationships (LWR) is an important tool for the adequate management of any fish species which have been applied in the assessment of fish stocks and populations. It is also useful in local and interregional morphological comparison of populations (Froese, 2006; Ali *et al.*, 2013). Length-weight relationship (LWR) data of fishes are useful for biologists (Martin-Smith, 1996) in fishery assessment and proper management of their population. It has been widely used in fish biology with several purposes: to predict weight from length measurements for yield assessment, to calculate the standing crop biomass, to estimate weight at age, stock assessment, to evaluate index of well-being of fish population, to assess age structure and function of fish populations, growth studies, to assess fish population dynamics and growth, to make morphometric comparisons between species and populations and life history comparisons between regions (Haimovici and Velasco, 2000; Morato *et al.*, 2001; Ozaydin *et al.*, 2007). LWR is used to obtain information about the condition of fishes in order to determine whether somatic growth is isometric or allometric (Gurkan and Taskavak, 2007; Ujjania *et al.*, 2012).

The study of the condition factor is important for understanding the life cycle of fish species and contributes to adequate management of these species and, therefore, to the maintenance of equilibrium in the ecosystem (Lizama *et al.*, 2002). Poorly conditioned fishes are associated with negative allometric growth, which implies that the fish becomes more slender as it increases in weight while fishes with appropriate condition factor have isometric growth, which implies that the fish becomes relatively deeper-bodied as it increases in length. The condition factor of fish can be affected by a number of factors such as stress, sex, season, availability of feeds, and other water quality parameters. The condition factor which shows the degree of well-being of the fish in their habitat is expressed by 'coefficient of condition' also known as length – weight factor. This factor is a measure of various ecological and biological factors such as degree of fitness, gonad development and the suitability of the environment with regard to the feeding condition. When condition factor value is higher it means that the fish has attained a better condition.

The condition factor of fish can be affected by a number of factors such as stress, sex, season, availability of feeds, and other water quality parameters (Khallafet *et al.*, 2003). Condition factor (K) is an important biological parameter, which indicates the suitability of a specific water body for growth of fish and an index of species average size (Alamet *et al.*, 2014). The values of this factor depend on physiological features of fish especially maturity, spawning, life cycle, environmental factors and food availability in a water body (Ujjania *et al.*, 2012; Dan-Kishiya, 2013). Thus this parameter is of great importance in fishery assessments, more importantly for proper exploitation and management of fish population (Haimovici and Velasco, 2000).

Materials and Methods

Study Area

Kiri reservoir is located on floodplain of lower Gongola River basin, about 25km upstream of its confluence with River Benue at Numan (Zemba, *et al.*, 2016). It was reported to have formed as a rift phase due to lithospheric peak thinning which caused long narrow depression that developed in some places filled with variety of sedimentary environment. Kiri Reservoir is on coordinate's 9°40'47"N 12°00'51"E on the southern part of Adamawa State, Nigeria. It is situated within Shelleng Local Government Area.

Sampling Period

This research was conducted for a period of eighteen months (September, 2017- February, 2019) using standard methods of measuring length-weight relationship and condition factor.

Determination of length-weight relationship of *O. niloticus* and *A. biscutatus*

The length-weight relationship was determined using conventional formula adopted by Kefas and Abubakar (2010).

$$W = aL^b$$

The equation and the data were transformed to logarithm before determination was made. The equation was therefore transformed into;

$$\log W = \log a + b \log L$$

Where, W = Weight of the fish in grams

L = Standard length of the fish in cm

a = constant

b = an exponent

Determination of condition factor of *O. niloticus* and *S. clarias*

The condition factor (k) was determined for individual fish using the conventional formula adopted by Ja'afaru and Tashara (2009). The ratio of the length to the weight of the fish was determined as;

$$K = \frac{W \times 100}{L^3}$$

Where, K = Condition factor

W = weight in grams

L = length in cm

Data Analysis

Data were subjected to descriptive statistics to establish mean, standard deviations and bar chart. One way analysis of variance (ANOVA) was used and significant variation was taken at 0.05 using SPSS. Length weight relationship was subjected to regression analysis.

Results

The 'b' value for the length-weight regression analyses of *O. niloticus* obtained from this study were sites A (1.2618), site B (1.3418) and site C (1.0757), all shown allometric growth (table 1). The length-weight relationship of site I, site II and site III showed linear relationship with significant correlation coefficient of 0.1617, 0.3714 and 0.039 for site A, B and C respectively. The result of length-weight regression analysis of *Auchenoglanis Biscutatus* is shown on table 1. The 'b' values for site A (2.3009), site B (2.1489) and site C (2.0677), sites A, B, C shown allometric growth. The length-weight relationship of site, site II and site III showed linear relationship with significant correlation coefficient of 0.7058, 0.5649 and 0.836 for sites A, B, C respectively.

Table 1: Length-weight Regression Analysis of *O. niloticus* and *A. biscutatus*

	Site	No. of Fish Examined	LogA	'b'	Correlation coefficient (r)
<i>O. niloticus</i>	A	54	0.6497	1.2618	0.1617
	B	54	0.4825	1.3418	0.3714
	C	54	0.6321	1.0757	0.039
<i>A. biscutatus</i>	A	54	- 0.7776	2.3009	0.7058
	B	54	- 0.5928	2.1489	0.5649
	C	54	- 0.5612	2.0677	0.836

The monthly mean condition factor of *O. niloticus* shows on table 2. The highest condition factor of 9.06 was recorded at site C in the month of September, 2018, while the lowest condition factor (1.29) was recorded at site A in the month of December, 2018. The monthly mean variation of the condition factor ranged from 2.773 in the month of December, 2018 to 5.136 in the month of September, 2018. Showing significant differences in months ($p < 0.05$). The value of mean across site A, B, and C showed no significant differences. The monthly mean condition factor of *Auchenoglanis Biscutatus* is shown on table 3. The highest condition factor of 2.47 was recorded at site A in the month of September, 2017 and October, 2018, while the lowest condition factor (0.86) was recorded at site A in the month of November, 2018. The monthly mean variation of the condition factor ranged from 1.086 in the month of May, 2017 to 2.266 in the month of April, 2017. The value of mean across months and site A, B and C showed no significant differences.

**Table 2: Monthly Mean Condition Factor of *O. niloticus* (cm)
September, 2017 – February, 2019 Reading Sites**

Months	Site A	Site B	Site C	Mean	STD
September, 2017	3.78	3.38	3.79	3.65	0.23
October	3.30	3.41	3.53	3.413	0.12
November	4.19	3.17	3.76	3.706	0.51
December	3.43	3.08	3.63	3.38	0.28
January, 2018	3.33	3.74	3.79	3.62	0.25
February	3.22	3.11	3.79	3.373	0.37
March	3.32	3.41	3.57	3.433	0.13
April	3.76	3.60	3.94	3.766	0.17
May	2.52	3.83	3.46	3.27	0.68
June	5.06	4.45	4.54	4.683	0.33
July	3.23	3.11	3.58	3.306	0.24
August	3.75	3.22	2.01	2.993	0.89
September	4.48	1.87	9.06	5.136	3.64
October	3.99	4.00	3.91	3.966	0.05
November	3.74	3.80	4.10	3.88	0.19
December	1.29	3.01	4.02	2.773	1.38
January, 2019	3.28	3.68	4.15	3.703	0.44
February	3.17	3.52	3.98	3.556	0.43
Mean	3.49	3.41	4.03		

**Table 3: Monthly Mean Condition Factor of *A. biscutatus* (cm)
September, 2017 – February, 2019 Reading Sites**

Months	Site A	Site B	Site C	Mean	STD
September, 2017	2.09	2.06	2.47	2.206	0.23
October	2.18	1.75	2.32	2.083	0.30
November	2.16	1.86	2.13	2.05	0.17
December	2.05	1.97	2.42	2.146	0.24
January, 2018	1.90	1.93	1.83	1.886	0.05
February	1.95	2.01	2.18	2.046	0.12
March	1.83	2.11	2.02	1.986	0.14
April	2.41	2.01	2.38	2.266	0.22
May	1.00	1.04	1.22	1.086	0.02
June	1.42	1.24	1.05	1.236	0.19
July	1.98	1.25	1.35	1.526	0.40
August	2.19	2.10	2.01	2.1	0.09
September	1.04	1.05	2.26	1.45	0.70
October	2.47	2.16	1.18	1.936	0.67
November	0.86	2.30	1.29	1.483	0.74
December	1.97	2.09	1.35	1.803	0.40
January, 2019	2.34	2.06	2.10	2.166	0.15
February	2.16	2.11	2.04	2.103	0.03
Mean	1.89	1.84	1.87		

Discussion

The result of length-weight regression analysis showed that the “b” values for both *O. niloticus* and *A. biscutatus* exhibited allometric growth pattern. The “b” values obtained indicate that increase in length is not equal proportion with the weight under constant specific gravity. The present study is similar to the observation for species of fish in Lake Geriyo in Adamawa State (Kefas and Abubakar, 2010; Kefas, 2016). Even though the change of b values depends primarily on the shape and fatness of the species, various factors may be responsible for differences in the b value for the length-weight relationships of cichlids (Atama *et al.*, 2013). These factors might include seasons, water temperature, salinity, food (quantity, quality and size), sex and stage of maturity. The variation experienced in the value of length-weight might be due to human activities such as; used of chemical and treated nets for fishing, activities of Hippopotamus, indiscriminate disposal of waste and open defecation. From length-weight parameters (a, b), fishes are affected by a series of factors such as season, habitat, gonad maturity, sex, diet, stomach fullness, health, preservation techniques and annual differences in environmental conditions (Onome *et al.*, 2013). The low alkalinity (2.1 – 23.5mg/L), low free CO₂ (0.0026 – 0.00792mg/L) and high ammonia (0.11 – 1.85mg/L) and phosphorus (0.11 – 0.88mg/L) during the period of this study in the reservoir might be responsible for allometric growth of the fish.

The mean monthly condition factor of *O. niloticus* and *A. biscutatus* indicated that both were in stable condition throughout the period of the research. The condition factor (K) gives information on the physiological state of the fish in relation to its welfare. A number of factors (e.g. sex, seasons, environmental conditions, stress and availability of food) are also affecting the condition of fish. Stress as a result of the reduction in the breeding and nursery ground of *O. niloticus* in the Lake Turkana, Kenya as contributing to dramatically lower condition factor. Pollution was seen to affect the condition of *O. niloticus* in Lake Marriut, Egypt (Golam and Fahad, 2013). The current result is higher than 2.23 and 1.99 reported for *O. niloticus* and *C. gariepinus* from Lake Geriyo (Kefas, 2016). This varied with the work of Zira *et al.* (2015), who reported an increase in condition factor during dry season as a result of water clarity, more light penetrates the water and photosynthetic plants flourish from Kiri reservoir. Variation in condition factor with pollution and season was also been reported for Shanawan drainage canal in Egypt (Khallaf, *et al.*, 2003). Therefore, the value obtained across site does not differ significantly throughout the period, but varies across month with reference to season. This could be due to slight variation in the physicochemical parameters and the concentration of Heavy metals which resulted from the human activities during the period of this study.

Conclusion

In conclusion, length-weight regression analysis showed that *O. niloticus* and *A. biscutatus* exhibited allometric growth pattern. The mean condition factor revealed that all the fish were in a stable condition.

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References

- Akinsanya, B., Otubanjo, O. A. and Ibidapo, C. A. (2007). Helminthbioload and length frequency distribution of *Chrysichthys nigrodigitatus* (Lacepede 1802) from Lekki Lagoon Lagos, Nigeria. *Turkish Journal of Fisheries and Aquatic Sciences*, **7**:83-87.
- Ali, A.N., Dahanukar, R. and Raghavan, (2013). Length-weight and length-length relationship of three species of snakehead fish, *Channadiplogramma*, *C.marulius* and *C. striata* from the riverine reaches of Lake Vembanad, Kerala, India. *Journal of Threatened Taxa*, **5**(13), 4769–4773.
- Alam, M. M., Rahman, M. T. and Parween, S. (2014). Morphometric characters and condition factors of five freshwater fishes from Pagla River of Bangladesh. *International Journal of Aquatic Biology*, **2**(1), 14-19.
- Atama, C.I., Okeke, O.C., Eken, F.N., Ezenwaji, N.E., Onah, I.E., Ivoke, N. *et al.* (2013) Length-Weight Relationship and Condition Factor of Six Cichlid (Cichilidae: Perciformis) Species of Anambra River, Nigeria. *Journal of Fisheries and Aquaculture*, **4**(2): 82-86.
- Dan-Kishiya, A. S. (2013). Lengthweight relationship and condition factor of five fish species from a tropical water supply reservoir in Abuja, Nigeria. *American Journal of Research Communication*, **1**(9):175- 187.
- Froese, R. (2006). Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology*, **22**(4): 241-253.
- Gurkan, S. and Taskavak, E. (2007). Length-weight relationships for syngnathid fishes of the Aegean Sea, Turkey. *Belgian Journal of Zoology*, **137**(2):219.
- Haimovici, M. and Velasco, G. (2000). Length-weight relationship of marine fishes from southern Brazil. *Naga, The ICLARM Quarterly*, **23**(1):19-23.
- Kefas, M. and Abubakar, K.A. (2010). Some aspects of Biological status of *C. gariepinus* in River Ilagil, Ngurore, Yola South Local Government Area, Adamawa State, Nigeria. *International Journal of Biological Science*, **2**(7): 82-86.
- Kefas, M. (2016). Incidence of Pollution and its Effects on *Clarias gariepinus* and *Oreochromis niloticus* in Lake Geriyo, Yola, Adamawa State, Nigeria. Doctoral Thesis, Modibbo Adama University of Technology, Yola, Nigeria.
- Khallaf, E., Galal, M. and Athuman, M. (2003). The biology of *Oreochromis niloticus* in a polluted canal. *Ecotoxicology*, **12**:405-416.
- Kohler, N., Casey, J. and Turner, P. (1995). Length-weight relationships for 13 species of sharks from the western North Atlantic. *Fish Bulletin*, **93**:412-418.
- Ja'afaru, A., and Tashara, A.T. (2009). Some Aspect of the Biology of *Auchenoglanis occidentalis* from River Benue at Yola, Adamawa State, Nigeria. *Nigerian Journal of Tropical Agriculture*, **11**: 296-304.
- Lizama, M. de los A. P. and Ambrósio, A. M. (2002). condition factor in nine species of fish of the characidae family in the upper paraná river floodplain, *Brazilian Journal Biology*, **62**(1):113-124.
- Martin-Smith, K. M. (1996). Length/weight relationships of fishes in a diverse tropical fresh-water community, Sabah, Malaysia. *Journal of Fish Biology*, **49**:731-734.
- Morato, T., Afonso, P., Lourinho, P., Barreiros, J. P. and Santos, R. S., *et al.* (2001). Lengthweight relationships for 21 coastal fish species of the Azores, North-eastern Atlantic. *Fisheries Research*, **50**:297-302.
- Onome, A.D., Charles, C.T. and Keme-Iderikumo, K. (2013). Length –Weight Relationship, Condition Factor and Sex Ratio of *Clarias gariepinus* Juveniles Reared in Concrete Tanks. *International Journal of Scientific Research in Environmental Sciences*, **1**(11): 324-329.
- Ozaydin, O., Uckun, D., Akalin, S., Leblebici, S. and Tosunoglu, Z. (2007). Length-weight relationships of fishes captured from Izmir Bay, Central Aegean Sea.
- Safran, P. (1992). Theoretical analysis of the weight-length relationships in the juveniles. *Marine Biology*, **112**:545-551.
- Ujjania, N. C., Kohli, M. P. S. and Sharma, L. L., (2012). Length-weight relationship and condition factors of Indian major carps (*Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*) in Mahi Bajaj Sagar, India. *Research Journal of Biology*, **2**(1):30-36.

- Wang, T., Wang, H. S., Sun, G. W., Huang, D. and Shen, J. H. (2012). Length-weight and length-length relationships for some Yangtze River fishes in Tian-e-zhou Oxbow, China. *Journal of Applied Ichthyology***28**:660-662.
- Zira J.D., Abubakar, K.A., Ja'afaru, A. and Elisha, D.S. (2015). Length-weight Relationship and Condition Factor of *Clarias gariepinus* (Burchell, 1822) from Kiri reservoir, Adamawa state, Nigeria. *International Journal of Fisheries and Aquatic Studies*,3(2): 471-475.

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Detection and Quantification of PAHs in *Thyrsites atun* (South African Snoek) and *Galeorhinus galeus* (Soupfin shark): A comparison of GC-MS/MS and UPLC-FLD methods

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Abstract

Polycyclic aromatic hydrocarbons (PAHs) of health concern have been detected and quantified in the aquatic environment. Through natural and anthropogenic activities, carcinogenic and toxic PAHs can accumulate in aquatic organisms such as fish. This study compared the methods of detection and quantification of 16 priority PAHs in marine fish species (*T. atun* and *G. galeus*) using gas chromatography-tandem mass spectrometry (GC-MS/MS) and ultra-performance liquid chromatography with fluorescence detection (UPLC-FLD). In *T. atun* GC-MS/MS detected only 4 PAHs, whilst UPLC-FLD detected 9 PAHs. Also, disparity was observed with *G. galeus* where GC-MS/MS detected 4 PAHs and UPLC-FLD detected 5. For lowest limit of detection, GC-MS/MS had 0.56 µg/kg (acenaphthene) while LC-FLD was 0.004µg/kg (benzo (*g,h,i*) perylene). Total PAHs concentrations in *T. atun* using GC-MS/MS or UPLC-FLD showed no significant variation ($p > 0.05$) whereas in *G. Galeus* GC-MS/MS it was significantly higher ($p < 0.05$) than the one measured with UPLC-FLD. Intra-class correlation of the two methods revealed an agreement ranged from 0.03 to 0.98 and consistency ranged from 0.23 - 0.98 in *T. atun*; while in *G. galeus* the agreement range was 0.02 to 0.63, consistency: 0.04 – 69. Both methods showed that *T. Atun* had higher ($p = 0.000$) PAHs concentration than *G. galeus*, input source of PAHs as petrogenic with dominance of non-carcinogenic PAHs especially naphthalene, no-detection of benzo (*a*) pyrene (EU PAHs fish acceptability indicator).

Keywords: PAHs, Marine-Fish, GC-MS/MS, UPLC/FLD, Detection and Quantification

Introduction

Polycyclic aromatic hydrocarbons (PAHs) have been identified to be of health concern due to their toxic, carcinogenic and mutagenic effects to humans and other organisms (FSAI, 2009). PAHs are lipophilic and weakly soluble in water which decreases with increase in the number of benzene rings (Skupinska *et al.*, 2004). PAHs are grouped into two: toxic or low Molecular weight (LMW) PAHs, with 2-3 benzene rings and carcinogenic or high molecular weight (HMW) PAHs with 4-6 benzene rings. Environmental sources include coal, petroleum, crude oil deposits and anthropogenic activities such as wild fire, domestic, municipal and industrial incineration (USEPA, 2008). Marine fish species have been reported to contribute significantly to human dietary exposure to PAHs (Domingo, 2007; Cheung *et al.*, 2007). PAHs accumulation in fish undermines the nutritional health benefits associated with fish consumption such as good sources of amino acids and polyunsaturated fatty acids (Usydu *et al.*, 2009).

Consumption of safe aquatic foods e.g. fish may require assessment and monitoring of these contaminants (USEPA, 2000) against limits provided by local and international regulatory agencies. The sensitivity and selectivity of analytical instruments used for analyses must be considered (Wise *et al.*, 2015) to ensure credibility. This study compared the assessment of priority PAHs in a single extraction but with diverse detection and measurement techniques of gas chromatography-tandem mass spectrometry (GC-MS/MS) and Ultra-Performance Liquid Chromatography with fluorescence detection (UPLC-FLD).

Materials and Methods

T. atun and *G. galeus* used for this study had average weights of 4.041 ± 0.42 kg and 7.440 ± 0.31 kg, and average length of 103.05 ± 4.56 cm and 115.50 ± 15.44 cm respectively. Fish samples (10 per species) were harvested by local line fishermen from Port Elizabeth (33.9581° S, 25.6000° E) in South Africa and were conveyed in crates (covered with ice) to the Stellenbosch University laboratory. Each fish was thoroughly washed (after measurements), de-headed, eviscerated, skinned and filleted. The fillets were homogenized on an individual basis,

vacuum packed and stored at -20°C pending further chemical analysis. Target analytes (sixteen US priority PAHs) were extracted following the modified QuEChERS method as detailed in Rufina *et al.* (2017) while the instrumental analysis of GC-MS/MS and UPLC-FLD were carried out according to modified methods of Kalachova *et al.* (2012) and Pule *et al.* (2012). All chemicals and standards used were of high purity and analytical grade. Quality control measures were adhered to using certified reference material and interferences monitored using blank procedural samples. Data generated were subjected to appropriate statistical analysis after testing for normality. Post hoc separation of means was done and significant differences established at 95% confidence level ($p < 0.05$). Only PAHs commonly detected by both methods were analyzed while PAHs below limits of detection (LOD) were treated as not detected (ND). A reliability test of data was done with intra-class correlation (ICC) by comparing the ratings of individual PAHs measured by GC versus LC against the total ratings.

Results

Both methods (GC-MS/MS and UPLC-FLD) successfully separated the 16 PAHs (using reference standards) within a run time of 31 and 20 min respectively. The UPLC-FLD gave a lower LOD of 0.004 µg/kg (benzo (*g,h,i*)) than the GC-MS/MS of 0.56 µg/kg wet weight (acenaphthene), Table 1. The GC-MS/MS did not have co-elution of any of the analysed 16 PAHs (certified reference standards), whereas with the UPLC-FLD, acenaphthene co-eluted with the internal standard (deuterated acenaphthene) and dibenzo (*a,h*) anthracene co-eluted with indeno (*1,2,3-cd*) perylene. UPLC-FLD did not detect acenaphthylene but GC-MS/MS did. For the fish samples: with *T. atun*, the GC-MS/MS detected 3 LMW PAHs (naphthalene, fluorine, phenanthrene) and one HMW PAH (pyrene), while the UPLC-FLD detected 4 LMW PAHs (naphthalene, fluorine, phenanthrene, anthracene) and fluoranthene, pyrene, chrysene, benz(*k*)fluoranthene and indeno(*1,2,3-cd*) perylene. Also UPLC-FLD detected more number of high molecular weight (HMW) PAHs (fluoranthene, pyrene, chrysene, benzo(*k*)fluoranthene and indeno (*1,2,3-cd*) perylene) than GC-MS/MS (pyrene) in the same sample. For the *G. galeus*, GC-MS/MS detected the same LMW PAHs (naphthalene, fluorene, phenanthrene and anthracene) as the UPLC-LD but no HMW PAHs while the UPLC-FLD detected one HMW PAH (pyrene).

The total PAHs as quantified with the GC-MS/MS in the *T. atun* samples (122.94 ± 10.65 µg/kg ww) was not significantly different ($p > 0.05$) from that quantified with the LC/FLD (144.18 ± 10.65 µg/kg ww). Conversely, in *G. galeus* total PAHs concentration with GC-MS/MS (113.49 ± 4.26 µg/kg ww) was significantly higher ($p < 0.05$) than that measured with UPLC-FLD (100.67 ± 3.72 µg/kg ww). In all, both methods revealed that *T. atun* had higher PAHs concentration than *G. galeus*, there is the dominance of LMW PAHs confirming input source as petrogenic with the ratio of LMW/HMW > 1 in both species and non-detection of PAHs biomarker benzo(*a*)pyrene in all the samples. To further determine the validity of the data, only PAHs detected by both methods (e.g. GC-naphthalene versus LC-naphthalene) were compared using intra-class correlation (ICC). The ICC values obtained (Table 2) apart from fluoranthene, ranged from 0.43 (naphthalene) to 0.98 (fluorine).

Table 1: Identification and quantification parameters. Limits of detection (LOD) and quantification (LOQ), retention time (RT) and R^2 values of each analyte (16 priority PAHs) as analyzed with gas chromatography/mass spectrometer (GC-MS/MS) and Liquid chromatography/Fluorescence detector (UPLC-FLD).

PAHs	GC-MS/MS				UPLC-FLD			
	LOD (µg/kg)	LOQ (µg/kg)	R^2	RT in min	LOD (µg/kg)	LOQ (µg/kg)	R^2	RT in min
Naphthalene	3.315	11.049	0.997	7.85	0.010	0.034	0.999	6.84
Acenaphthylene	1.102	3.674	0.998	12.05	Not Det.			
Acenaphthene	0.556	1.852	0.996	12.50	Coelution	Coelution		8.77
Fluorene	1.617	5.389	0.997	13.77	0.010	0.034	0.998	8.81
Phenanthrene	2.257	7.525	0.99	16.06	0.009	0.031	0.999	9.33
Anthracene	1.349	4.495	0.991	16.18	0.009	0.029	0.998	9.66
Fluoranthene	2.404	8.013	0.994	18.90	0.009	0.030	0.999	10.6
Pyrene	1.737	5.788	0.992	19.41	0.007	0.024	0.999	10.94
Chrysene	2.835	9.449	0.991	22.30	0.013	0.043	0.999	12.35
Benzo(<i>a</i>)anthracene	2.274	7.581	0.992	22.38	0.010	0.032	0.999	12.55
Benzo(<i>b</i>)fluoranthene	1.666	5.552	0.997	24.69	0.006	0.020	0.999	14.22
Benzo(<i>k</i>)fluoranthene	1.532	5.107	0.996	24.75	0.009	0.029	0.999	14.47
Benzo(<i>a</i>)pyrene	2.369	7.896	0.996	25.34	0.007	0.022	0.999	14.77
Indeno(<i>1,2,3-cd</i>)pyrene	2.089	7.896	0.997	27.43	0.010	0.033	0.999	17.12
Dibenz(<i>a,h</i>)anthracene	1.774	5.912	0.997	27.49	Coelution			

Benzo(<i>g,h,i</i>)perylene	1.537	5.123	0.998	27.86	0.004	0.012	0.999	16.37
Table 2: PAHs ($\mu\text{g/kg}$ wet weight) commonly detected in <i>Thyrsites atun</i> and <i>Galeorhinus galeus</i>, as quantified using GC-MS/MS and UPLC-FLD, showing p-value, intra-class agreement and consistency between the two methods and r- values based on intra-class correlation (ICC).								
Species	PAHs	GC-MS/MS $\mu\text{g/kg ww}$	UPLC-FLD $\mu\text{g/kg ww}$	p-value	Agreement	Consistency	r-value	
<i>T.atun</i>	Naphthalene	108.63 $\pm$ 10.63	129.29 $\pm$ 12.34	0.11	0.43	0.48	0.37	
	Fluorene	5.03 $\pm$ 1.84	5.29 $\pm$ 1.59	0.50	0.98	0.98	0.77	
	Phenanthrene	7.79 $\pm$ 0.97	7.20 $\pm$ 1.14	0.37	0.82	0.82	0.61	
	Fluoranthene	0.28 $\pm$ 0.5	1.08 $\pm$ 0.08	0.03	0.03	0.23	0.43	
	Pyrene	1.20 $\pm$ 0.13	1.32 $\pm$ 0.15	0.46	0.43	0.42	0.37	
	Σ PAHs	122.94 $\pm$ 9.96	144.18 $\pm$ 11.29	0.11	0.32	0.34	0.30	
<i>G.galeus</i>	Naphthalene	102.29 $\pm$ 2.68	97.71 $\pm$ 3.58	0.10	0.63	0.69	0.52	
	Fluorene	2.39 $\pm$ 0.22	2.23 $\pm$ 0.18	0.55	0.21	0.20	0.07	
	Phenanthrene	8.81 $\pm$ 2.73	0.73 $\pm$ 0.09	0.02	0.02	0.04	0.58	
	Σ PAHs	113.49 $\pm$ 4.26	100.67 $\pm$ 3.72	0.001	0.50	0.78	0.85	

Discussion

The run times for both the GC-MS/MS and UPLC-FLD observed in this study were within acceptable limits as reported in Pule *et al.* (2012) and Ramalhosa *et al.* (2009). In general, total PAHs concentration could be affected by factors associated with experimental methodology (such as properties of the analytes), or with biological factors such as fish size and species (USEPA, 2000). Different fish species have different abilities to metabolize PAHs which may affect the residual levels (Gert-Jan de Maagd & Vethaak, 1998). Comparison of the current study with published data is limited as data under similar analytical conditions are scarce. Berset *et al.* (1999) reported HRGC-MS/MS as superior to UPLC-FLD in measuring PAHs in a soil matrix, whereas Wise *et al.* (2015) reported LC to be more sensitive and selective in PAHs analysis (in a biological matrix) if an appropriate column is used. In this study, the UPLC-FLD detected a higher number of PAHs profiles, especially more of the carcinogenic (HMW) PAHs and had lower limits of detection than the GC-MS/MS.

The dominance of LMW (non-carcinogenic) PAHs, particularly naphthalene, in the investigated marine species confirms a petrogenic input sources. Degger *et al.* (2011) also reported that the South African marine environment was contaminated with PAHs from petroleum sources (petrogenic). However, some large fish species (of the types studied) can enzymatically metabolize and excrete the HMW PAHs (Gert-Jan de Maagd & Vethaak, 1998), which may have contributed to the observed low detection and concentrations of HMW in studied species by both methods. Both methods revealed that *T.atun* had higher level of PAHs contamination than the *G.galeus*. This could be attributed to the possibility of *G.galeus* to metabolize and excrete PAHs more efficiently than *T.atun*. However, both postulations require further investigation to have a clear understanding of species specificity in accumulation of PAHs.

Conclusion

The ability of the UPLC-FLD to detect both LMW and HMW PAHs (based on this study) would suggest it is superior to GC-MS/MS in PAHs profiling. The UPLC-FLD with lower detection limit could be an explanation to its detection of more PAHs in comparison to the GC-MS/MS. However, there were co-elution of some PAHs with internal standards observed only with the UPLC-FLD. It may become necessary to combine both methods for validation if more sensitive assessments are required. It is recommended that such assessments though very expensive be carried out on our aquatic species in Nigeria, considering the high level of oil pollution in our coastal waters.

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References

- Besert, J. D., Ejem, M. Holzer, R. & Lischer, P. (1999). Comparison of different drying, extraction and detection techniques for the determination of priority polycyclic aromatic hydrocarbons in background contaminated soil samples. *Analytica Chimica Acta*, **383**, (3), 263-275
- Cheung, K. C., Leung, H. M., Kong, K.Y. & Wong, M. H. (2007). Residual levels of DDTs and PAHs in freshwater and marine fish from Hong Kong markets and their health risk assessment. *Chemosphere*, **66**, 460–8.
- Degger, N., Wepener, V., Richardson, B.J. & Wu, R. S. S. (2011). Brown mussels (*Perna perna*) and semi-permeable membrane devices (SPMDs) as indicators of organic pollutants in the South African marine environment. *Marine Pollution Bulletin*, **63**, 91–7.
- Domingo, J. L. (2007). Health risks arising from the dietary intake of chemical contaminants: a case study of the consumption of edible marine species in Catalonia , NE Spain. *Contributions to Science*, **3**(4), 459–468.
- FSAI, (2009). Polycyclic Aromatic Hydrocarbons (PAHs) in Food. Toxicology Factsheet Series. Food Safety Authority of Ireland. Pp1-9.
- Gert-Jan de Maagd, P. & Vethaak, A.D. (1998). Biotransformation of PAHs and their Carcinogenic Effects in Fish. The Handbook of Environmental Chemistry, 3, Part J, In: PAHs and related Compounds: Biology (ed. Neilson. A.H.), Springer Science & Business Media. Pp. 266-300.
- Kalachova, K., Pulkrabova, J., Cajka, T., Drabova, L. & Hajslova, J. (2012). Implementation of comprehensive two-dimensional gas chromatography-time-of-flight mass spectrometry for the simultaneous determination of halogenated contaminants and polycyclic aromatic hydrocarbons in fish. *Analytical Bioanalytical Chemistry*, **403**, 2813-2824.
- Pule, B. O., Mmualefe, L. C. & Torto, N. (2012). Analysis of Polycyclic Aromatic Hydrocarbons in Fish with Agilent Bond Elut QuEChERS AOAC Kit and HPLC-FLD. *Agilent Technologies Publication*, **1–8**, 5990-5441.
- Ramalhosa, M. J., Paíga, P., Morais, S., Delerue-Matos, C. & Oliveira, M. B. P. P. (2009). Analysis of polycyclic aromatic hydrocarbons in fish: evaluation of a quick, easy, cheap, effective, rugged, and safe extraction method. *Journal of Sep Science*, **32**, 3529–38.
- Rufina C.C., Hoffman C.L., Opara L.U., O’Neil B., Stander A.M. (2017). Polycyclic Aromatic Hydrocarbons (PAHs) and Organochlorinated Pesticides (OCPs) in Yellowtail *Seriolalandi* from three Spatially Distinct Locations along the Coast of South Africa: Levels, Sources and Fish Size Effect. *Journal of Food Process. Technol.* 8:644. doi:10.4172/2157-7110.1000644.
- Skupińska, K., Misiewicz, I. & Kasprzycka-Guttman, T. (2004). Polycyclic Aromatic Hydrocarbons: Physiocochemical Properties, Environmental Appearance and Impact of Living Organisms. *Acta Poloniae Pharmaceutica-Drug Research*, **61**(3), 233-240.
- USEPA, (2000). United States Environmental Protection Agency. Guidance for Assessing Chemical Contaminant Data for use in Fish Advisories, Vol. 2, Risk Assessment and Fish Consumption Limits 3rd ed. EPA, 823, B, 00-008. Washington, DC. Pp1-383.
- USEPA, (2008). United States Environmental Protection Agency. Polycyclic Aromatic Hydrocarbons (PAHs). Office of Solid wastes, Washington DC. Pp. 1–3.
- Usydus, Z., Szlinder-Richert, J. & Adamczyk, M. (2009). Protein quality and amino acids profiles of fish products available in Poland. *Food Chemistry*, **112**, 139-145.
- Wise, S. A., Sander, L.C. & Scahntz, M. M. (2015). Analytical Methods for Determination of Polycyclic aromatic hydrocarbons (PAHs)-A Historical Perspective on the 16 U.S. EPA priority pollutant PAHs. *Polycyclic Aromatic Compounds*, **35**, 187-246.

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Fish Catch Assessment of Southern Portion of Kainji Lake in Yuna, Borgu Local Government Area of Niger State

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Abstract

The fish catch assessment of southern portion of Kainji Lake was conducted at Yuna, a fishing community to provide technical information for sustainable fish production. Descriptive Statistics was used to analyze the catch data. A total of 407 fishes were assessed. Forty eight (48) fish species belonging to sixteen (16) families were identified. Percentage gear catch composition was 26.29%, 30.96% and 42.75% for beach seine, gill net 1½” and gill net 2” respectively. The total average annual fish catch for Yuna was estimated at 46 tonnes during the period of study. Mochokidae had the highest diversity with 9 species. Mormyridae was the most relatively abundant family (22.9%) with *Mormyrus rume* that registered the highest percentage abundance in terms of number. Beach seine (dala), which has a negative impact on the fisheries, is still being intensively employed by fishers. The resultant effect is evident in the catches where majority of the landings are juvenile/immature individuals. The ban on beach seine needed to be reinforced completely on the Lake to boost production. The farmers had keyed into the idea of making ponds along the Lake shore to engage in the fish farming practices. This is a welcome development which could help the fisheries of the Lake but has to be done with the technical assistance from NIFFR.

Key words: Catch assessment, Fisheries, Fishing gear and Fish yields.

Introduction

Catch assessment is a designed approach used to source information required for the improvement, monitoring and management of fisheries of water bodies. Analysis of fish catch assessment helps to elucidate the prevailing status of the fishery of the water body while factors militating against the fishery are exposed for necessary mitigation. Such factors include over fishing through the use of obnoxious fishing gear.

Kainji Lake is located between longitude 4° 21' and 4° 45' East and latitude 9° 5' and 10° 55' North. It crosses, Niger and Kebbi States, with the greater part located in Niger State. It is the largest man-made lake in Nigeria created in 1968 following the impoundment of River Niger by the construction of the Kainji Dam. The dam was created for hydroelectric power generation. However, the reservoir created secondary economic opportunities, in particular fisheries, which attracted fishers from near and far both around the State and neighbouring countries of Benin and Niger republics (Ayanda and Alamu, 1991). Several studies had been carried out on the fishery of the Lake. Abiodun *et al.* (2013) worked on the fish species diversity of the Lake. The objectives of this study are to determine the current fish yields and assess fish composition, abundance and diversity of the southern portion of the Lake using Yuna, a fishing community in the Southern Basin, as the point of study.

Materials and Method

Fishers' catches at Yuna landing sites were assessed (Plates 1 and 2). Whenever a fisher landed with a canoe, fishes caught were identified using identification manual (Froese and Pauly, 2013) and sorted according to species. They were counted, and their weights taken using weighing scale and recorded on data sheets. The numbers of available fishing craft were obtained and the types of fishing gear used were also noted. An estimate of landings by few randomly selected fishers from the Yuna was used to get the landings estimate for this landing site at the southern portion, and projected for a month and the year.



Plate 1: Fishers landing with fish



Plate 2: Fisher's catch in a canoe

Results and Discussion

Table 1 shows 48 species of fish from 16 families recorded at the southern basin of the lake. Mochokidae had the highest diversity with 9 species, followed by Mormyridae with 7 species. Cichlidae, Schilbeidae were represented by 5 species each, Alestidae 4 while Claroteidae, Distichodontidae had 3 species each. Bagridae, Cyprinidae, Polypteridae had 2 species each while the remaining 6 families were represented by only 1 species each. The last study revealed 23 species in 15 families. This shows that the fish diversity of Kainji Lake southern basin is still high as shown by this study compared to that of Abiodun *et al.* (2013). Mormyridae was the most relatively abundant family(22.9%) with *Mormyrus rume* (10.57%) registering the highest percentage abundance in terms of number while the lowest were *Chromidotilapia guntheri*, *Heterotis niloticus*, *Synodontis membranaceus*, *Mormyrus macrophthalmus*, *Malapterurus electricus*, *Paradistichodus dimidiatus*, *Synodontis nigrita*, and *Synodontis sorex* with 0.25% each. Beach seine, a highly deleterious fishing gear (Plates 3), had been banned on the Lake during the GTZ intervention dispensation/era but has slowly crept back unto the Lake with its attendant problems. This has affected the fish population on the Lake resulting to poor catch experienced by the fishers. This has led to the practice of fish culture to complement their catch as shown in (plate4).

Estimate of Current Fish Yields- The analysis of 12 months catch assessment is required in order to obtain the current yield estimate of the Lake. Fifty four fishing canoes including 2 that were damaged were recorded in the course of the assessment, conducted at Yuna on the southern portion of the Lake. Fish catches from beach seine (Dala) being a very prominent gear employed on the Lake and gill nets were examined. Catches ranged between 1.7kg and 3.2kg/day/boat with average of 2.45kg. In an interview with the fishers, the fishing days varied between 29 and 31 days in a month. This gives an average of 30 days per month and 360 days per year. The projected yield for the year was therefore calculated according to Abiodun and Miller (2007).

Estimate of yield at Yuna:

52 fishing craft * 360 fishing days * 2.45kg/day = 45864kg.

Hence the total yield is estimated at 46 tonnes per annum with minimum and maximum values of 31 and 62 tonnes respectively.

Figure1 shows catch by beach seine (dala) and gill nets. Majority of the catch was from mesh 2" both in terms of number (42.75%) and weight (52.49%) overall. Beach seine of 2mm caught (26.29%) and (28.26%) by number and weight respectively, while mesh size 1½" caught (30.96%) and (19.25%) by number and weight respectively. This shows that meshes below 3" caught small sizes of fish, which was observed from the fishers' landing. The combination of catches from the beach seine and the small mesh sized gill nets exploited small sized fishes which often tend to growth overfishing. The impact of these is highly deleterious as stated earlier. A minimum mesh size of 3 inches (76.2 mm) has been recommended for gill net fishing (Ita, 1982)

Table 1: Fish composition, abundance and weight from southern basin of Kainji Lake

Family/Species	No	% No	Wt	% Wt
Mormyridae				
<i>Grathonemis deboensis</i>	17	4.18	650	2.16
<i>Marcusenius psittacus</i>	2	0.49	50	0.17
<i>Mormyrops deliciousus</i>	13	3.19	150	0.50
<i>mormyrus macrophthlmus</i>	1	0.25	50	0.17
<i>mormyrus rume</i>	43	10.57	2750	9.14
<i>Hyperopisus bebe</i>	14	3.44	875	2.91

<i>Marcusenius isidori</i>	3	0.74	111	0.37
Cyprinidae				
<i>Labeo coubie</i>	3	0.74	300	1.00
<i>Labeo parvus</i>	16	3.93	850	2.82
Cichlidae				
<i>Hemichromis Fasciatus</i>	7	1.72	350	1.16
<i>Oreochromis aureus</i>	9	2.21	300	1.00
<i>Tilapia zillii</i>	35	8.60	2200	7.31
<i>Chromidotilapia guenttheri</i>	1	0.25	50	0.17
<i>Tilapia dageti</i>	14	3.44	1550	5.15
Clariidae				
<i>Clarias gariepinus</i>	2	0.49	300	1.00
Polypteridae				
<i>Polypterus senegalus</i>	3	0.74	150	0.50
<i>Polypterus endlicheri</i>	9	2.21	1100	3.65
Osteoglossidae				
<i>Heterotis niloticus</i>	1	0.25	450	1.50
Alestidae				
<i>Brycinus leuciscus</i>	31	7.62	750	2.49
<i>Hydrocynus forskahlii</i>	3	0.74	900	2.99
<i>Alestes dentex</i>	3	0.74	100	0.33
<i>Brycinus macrolepidotus</i>	2	0.49	300	1.00
Distichodontidae				
<i>Distichodus brevipinnis</i>	10	2.46	400	1.33
<i>Distichodus rostratus</i>	7	1.72	1050	3.49
<i>Paradistichodus dimidiatus</i>	1	0.25	50	0.17
Citharinidae				
<i>Citharinus citharus</i>	9	2.21	1350	4.49
Bagridae				
<i>Bagrus bayad</i>	23	5.65	4450	14.79
<i>Bagrus docmac</i>	2	0.49	500	1.66
Malapteruridae				
<i>Malapterurus electricus</i>	1	0.25	900	2.99
Mochokidae				
<i>Synodontis budgetti</i>	5	1.23	200	0.66
<i>Synodontis batensoda</i>	3	0.74	300	1.00
<i>Synodontis membranaceus</i>	1	0.25	250	0.83
<i>Synodontis sorex</i>	1	0.25	200	0.66
<i>Synodontis vermiculatus</i>	2	0.49	150	0.50
<i>Synodontis schall</i>	8	1.97	200	0.66
<i>Synodontis nigrita</i>	1	0.25	25	0.08
<i>Synodontis gambiensis</i>	9	2.21	700	2.33
<i>Synodontis eupterus</i>	11	2.70	250	0.83
Schilbeldae				
<i>Parailia pellucida</i>	4	0.98	65	0.22
<i>Schilbe mystus</i>	6	1.47	80	0.27
<i>Schilbe intermedius</i>	6	1.47	155	0.52
<i>Schilbe uranoscopus</i>	16	3.93	50	0.17
<i>Siluranodon auritus</i>	3	0.74	137	0.46
Centropomide				
<i>Lates niloticus</i>	6	1.47	175	0.58
Clupeidae				

<i>Pellonula leonensis</i>	6	1.47	4	0.01
Claroteidae				
<i>Aucheriglanis occidentalis</i>	4	0.98	150	0.50
<i>Chrysichthys auratus</i>	3	0.74	200	0.66
<i>Chrysichthys nigrodigitatus</i>	27	6.63	3820	12.69
Total	407	100.00	30097	100.00

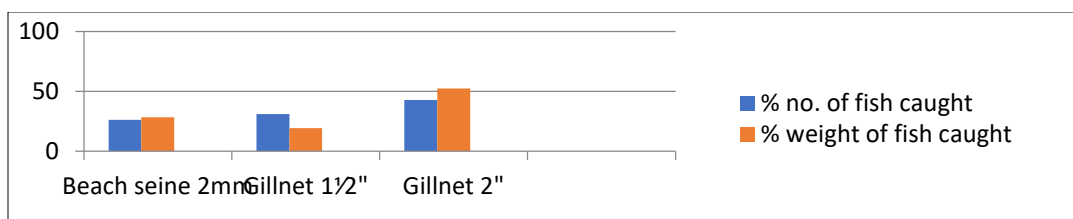


Figure 2: Percentage fish caught by beach seine and gill nets base on number and weight from Southern Basin of Kainji Lake



Plate 3: Beach seine (dala)



Plate 4: Fish ponds close to fishers' residence

Conclusion

The current fish estimate of Yuna fishing community is 46 tonnes per annum. The diversity is still high as represented at Yuna. Beach seine (dala), which has a negative impact on the fisheries, is still being intensively employed by fishers. The resultant effect is evident in the catches where majority of the landings were juvenile/immature individuals. Its combined use with 1½" and 2" meshes by the fishers are against the minimum mesh size of 3 inches recommended for inland water bodies. The ban on beach seine (dala) needed to be reinforced completely on the Lake to enable it recover from the onslaught of these gears. Fish farming should be introduced and encouraged along the Lake shoreline to boost production. As generally observed, the fishers had keyed into this idea making ponds along the Lake shore to engage in the fish farming practices. This is a welcome development which could help the fishery of Lake a lot. However this has to be properly done with the necessary technical assistance from NIFFR.

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We would like to express our profound gratitude to God for his guidance, protection and whose amazing grace brought this work to completion. We also thank NIFFR for funding this project.

References

- Abiodun, J.A., Yem, I.Y., Ibrahim, A., Apeloko, F.O. and Musa, F.A. (2013). Fishery Survey of Lake Kainji Southern Basin Nigeria 2012/2013 NIFFR Annual Report. p.37
- Abiodun, J.A and Miller, J.W. (2007). Assessment of Gerio Lake Fishery for enhanced management and improved fish production. *Journal of applied Science and Enviromental management*. ISSSN 1119-8362, Vol.11(14), December, 2007.
- Ayanda, J.O and Alamu, S.O. (1991). Preliminary investigation into the development and impact of fishermen's organization in the Kainji Lake basin. *National Institute for Freshwater Fisheries Research annual report*, pp 195-204.
- Froese, R. and Pauly, D. (2013). World Wide Web electronic publication. www.fishbase.org.
- Ita, E.O. (1982). Fisheries Survey of Tiga Lake, Kano State, Nigeria. *Kainji Lake Research Report*. ISSN 0331-9296, pp.67-74.

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Frame And Catch Assessment Surveys of the Fisheries of Omi Reservoir, Kogi State, Nigeria

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Abstract

Frame and Catch Assessment Surveys of the fisheries of Omi reservoir were carried out to provide data needed for its sustainable management and development. Descriptive statistics was used to analyse the data. A total of 1,239 species were assessed. 136 fishers with 38 assistants were recorded. 156 wooden canoes were counted and recorded. The fishing gears recorded include (597) gill nets, (79) cast nets, (229) long lines, (4,773) Malian fish traps, (2,756) wire fish traps and (99,300) bamboo fish traps. 14 fish species belonging to 10 families were identified. Alestidae was the most relatively abundant family contributing 52.7% to the number and 40.4% to the weight of the total fish caught on the reservoir while channidae was the lowest abundant family accounting for 0.24% and 0.31% in terms of number and weight respectively of the total fish caught. The current fish yield estimate of the reservoir is 9.73 tonnes per annum. This represent 3.9 kg/ha and considered very low. Recommendations were made for the management of the fisheries of the reservoir.

Key words: Frame survey, Catch assessment, Fisheries, Fishing gear and Fish yields.

Introduction

Frame and Catch Assessment Surveys of the fisheries of Omi reservoir were carried out to provide data needed for its sustainable management and development. There are many settlers particularly fishers around Omi reservoir and this reveals the fisheries potential of the reservoir. This potential can be fully realized through the generation and analysis of frame and catch data from the reservoir to meet the national goal of increase inland fish production and food security for improved livelihoods of the communities around the reservoir.

Omi reservoir is located in Yagba West Local Government Area of Kogi State. It is located between longitudes 6°37' and 6°42' E and latitudes 8°34' and 8°38' N (Adeniran *et al.*, 2010). The reservoir with capacity of 250 million cubic metres has a surface area of 2500 hectares. It was created in 1999 primary for irrigation to boost agriculture following the construction of Omi dam. The reservoir, however, created secondary opportunities, in particular fisheries. Several studies had been conducted on the reservoir. Ovie *et al.* (2008) worked on Limnological Stock Assessment, Productivity and Potential Fish Yield. Bankole *et al.* (2008) reported on Fishery Survey of the reservoir. The objectives of this study are to determine the size and distribution of fishing localities, fishers, fishing crafts and fishing gears and also assess the fish composition, abundance, species diversity and the current fish yield of Omi reservoir.

Materials and Method

Data were collected from all the fishing villages using structural questionnaires and interviews with the secretary of the Fishers' Association and some randomly selected fishers for frame survey. Total count and listing of all the fishing villages, fishers and fishing equipment operating on the reservoir were made. During the catch assessment, fishers' catches at Omi, Ogga, Okere and Ogbe landing sites were assessed (plates 1 and 2). Whenever a fisher landed with a canoe, fishes caught were identified and sorted according to species and the gear type used. They were counted and their weights taken using weighing balance and recorded on data sheet. The landing prices of all the fish species identified were also recorded.



Plate 1: Fisher landing with her catch



Plate 2: Fisher's catch

Results and Discussion

Frame Survey - There are four fishing villages located around the reservoir: Omi, Okere, Ogga and Ogbe. The fishing landing sites visited included Omi, Okere and Ogga landing sites. Table 1 shows the distribution of the fishers, their fishing crafts and gears. A total of 136 fishers comprise 113 fishermen and 23 fisherwomen, with 58 assistants were counted and recorded. A total of 39 fishers were recorded in Omi, 54 in Okere, 38 in Ogga and 5 in Ogbe. Henderson and Welcome, (1974) recommended a density of two (2) fishers per square kilometre. Based on this, only 50 fishers should have been registered to fish on the reservoir with a surface area of 25 square kilometres, however, 136 were recorded during the survey.

One hundred and fifty six (156) wooden canoes were counted and recorded. The fishing gears recorded include (597) gill nets, (79) cast nets, (229) long lines, (4773) Malian fish traps, (2756) wire fish traps and (99,300) bamboo fish traps.

The fishing gears operated by the fishers on the reservoir include bamboo fish traps. A truck of bamboo poles contains two hundred poles, and twelve bamboo fish traps are made from each pole. Each fisher who operated bamboo fish trap on the reservoir used at least a truck of bamboo poles for construction of the fish traps. This explains the reason a large number was recorded. A bamboo fish trap catches at most two fishes per setting.

Catch Assessment – Table 2 shows 14 species from 10 families in Omi reservoir. Alestidae was the most relatively abundant family contributing 52.7% to the number and 40.4% to the weight of the total fish caught on the reservoir while channidae was the lowest abundant family accounting for 0.24% and 0.31% in terms of number and weight respectively of the total fish caught. Considering fish species diversity, the family Cichlidae - *Hemichromis fasciatus*, *Tilapia zilli*, and *Sarotherodon galilaeus* had the highest with three species followed by Clarotidae - *Chrysichthys auratus* and *Auchenoglanis occidentalis*; Mormyridae - *Mormyrops anguilloides* and *Petrocephalus bane* with two species each while the families Alestidae - *Brycinus nurse*; Anabantidae – *Ctenopoma kingsleyae*; Bagridae - *Bagrus bajad*; Cyprinidae - *Labeo coubie*; Malapteruridae - *Malapterurus electricus*; and Schilbeidae -

Schilbe mystus had the lowest with one species each. An earlier survey conducted on the reservoir revealed 6 families and 9 different species. There is slight improvement in species diversity over the years but still considered low compared with the findings of Yem *et al.* (2016) with 10 families and 23 fish species from Goronyo Reservoir. The mean sizes of fish caught by the fishers during the assessment revealed that they were using mostly small mesh size nets. This is evident in the fishers' catches. A minimum mesh size of 3 inches (76.2 mm) has been recommended for gill net fishing (Ita, 1982)

Approximate Estimate of Current Fish Yields

Catches by gillnets, cast nets, long-lines, Malian fish traps, wire fish traps, bamboo fish traps from the reservoir were examined during the sampling periods. The catch per unit effort (CPUE) was 3.9 kg per fishing day and average of 8 boats were operated per day. In an interview fishers, the fishing activities take place about 26 days in a month. An approximate yield was therefore calculated (Abiodun *et al.*, 2014).

Total catch = Total fishing effort * Catch per unit effort 1

But Fishing effort = Fcap * BAC * A 2

Where Fcap = Fishing capacity (the total number of fishing boats that are potentially operating at all fishing sites)

BAC = Boat Activity Coefficient (the probability that any boat will be active on any day during the month)

A = A raising time factor expressing total number of days that fishing activities take place during the month.

From equation (2) above,

Fishing effort = 156 * 8/156 * 26 = 208 boat days. Hence, total catch = 208 * 3.9kg = 811.2kg/month. The current annual fish yield of Omi reservoir = 811.2 * 12 = 9,734 kg. The current fish yield estimate of the reservoir is 9,734kg. This represents 3.9 kg/ha and considered very low in comparison with some other similar water bodies in Nigeria like IITA reservoir in Oyo State with 282 kg/ha (Ita, 1993) and Kiri reservoir in Adamawa State with 215 kg/ha (Ita, 1993).

Table 2: Fish composition, abundance and weight on Omi reservoir

Family/Species	No	% No	Wt	% Wt	Mean Weight
Alestidae					
<i>Brycinus nurse</i>	653	52.70	25.00	40.37	0.04
Anabantidae					
<i>Ctenopoma kingsleyae</i>	17	1.37	1.30	2.10	0.08
Bagridae					
<i>Bagrus bayad</i>	23	1.86	9.20	14.86	0.40
Channidae					
<i>Parachanna obscura</i>	3	0.24	0.31	0.50	0.10
Cichlidae					
<i>Hemichromis Faciatus</i>	59	4.76	1.30	2.10	0.02
<i>Tilapia Zilli</i>	177	14.29	5.20	8.40	0.03
<i>Sarotherodon galilaeus</i>	16	1.29	0.44	0.71	0.03
Claroteidae					
<i>Chrysichthys auratus</i>	208	16.79	8.41	13.58	0.04
<i>Auchenoglanis occidentalis</i>	20	1.61	2.40	3.88	0.12
Cyprinidae					
<i>Labeo coubie</i>	16	1.29	1.72	2.78	0.11
Malapteruridae					

<i>Malapterurus electricus</i>	6	0.48	0.50	0.81	0.08
Mormyridae					
<i>Mormyrops anguilloides</i>	10	0.81	1.21	1.95	0.12
<i>Petrocephalus bane</i>	2	0.16	0.01	0.02	0.01
Schilbeidae					
<i>Schilbe mystus</i>	29	2.34	4.92	7.95	0.17
Total	1,239	100	61.92	100	

Conclusion and Recommendation

The current fish yield estimate from the reservoir based on the catch assessment data collected from the landings of the fishers is 9.73 tonnes per annum. This represents 3.9 kg/ha and considered very low. The low production observed calls for re-restocking of the reservoir with indigenous fish species to enhance its productivity.

The mean weights of fish caught by the fishers during the assessment indicated that they were using mostly small mesh size nets. A minimum mesh size of 3" has been recommended for gill net fishing. This should therefore be enforced to allow effective growth of all the fish species before exploitation.

With surface area of 25 km², only about 50 fishers should have been registered to fish on the reservoir based on (Henderson and Welcomme, 1974) recommendation of a density of two (2) fishers per square kilometer. The estimated 136 fishers and 58 assistants operating on the reservoir could lead to overfishing of the stock. It is important that Lower River Niger Basin Development Authority controls the number of boats and fishers through a licensing system. The fish species diversity of the reservoir needs to be increased by restocking it with the following indigenous fish species *Clarias gariepinus*, *Polypterus senegalus*, *Citharinus citharus*, *Oreochromis niloticus*, *Bagrus docmak*, *Mormyrus rume* to reduce the fishing pressure on the few available fish species in the reservoir.

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We would like to express our profound gratitude to God for his guidance, protection and whose amazing grace brought this work to completion. We also thank NIFFR for funding this project.

References

- Abiodun, J.A., Apeloko, F.O. and Musa, F.A. (2014). A Catch Assessment of Kontagora Reservoir, Niger State, Nigeria. *National Institute for Freshwater Fisheries Research Annual Report*, pp. 53-56.
- Adeneran, K.A., Amodu, M.F., Amodu, M.O. and Adeniji, F.A. (2010). Water Requirement of Some Selected Crop in Omi Dam Irrigation PROJECT, *Australia Journal of Agricultural Engineering*, Vol.1 (4), pp.119-125.
- Bankole, N.O., Yem, I.Y. and Apeloko, E.O. (2008). Fishery Survey of Omi Lake in Kogi State. *National Institute for Freshwater Fisheries Research Annual Report*, p.7
- Henderson, H.F. and Welcomme, R.L. (1974). The Relationship of Yield to Morphoedaphic Index and Number of Fishermen in African Inland Fisheries. *FAO/CIFA Occasional Paper*1, 19p.
- Ita, E.O.(1993). Inland Fisheries Resources of Nigeria. pp. 58-61.
- Ita, E.O. (1982). Fisheries Survey of Tiga Lake, Kano State, Nigeria. *Kainji Lake Research Report*. ISSN 0331-9296, pp.67-74.
- Ovie, S.I., Bwala, R.L. and Ajayi, O. (2008). A Preliminary Study on Limnological Stock Assessment, Productivity and Potential Fish Yield of Omi Dam. *National Institute for Freshwater Fisheries Research Annual Report*, p.13
- Yem, I.Y., Bankole, N.O., Ibrahim A. and Kwen, K. (2016). Ichthyofauna Survey of Goronyo Reservoir, Sokoto State, Nigeria. *FISON Conference proceedings*, pp.255-258

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Seasonal Comparative Study of Some Aspect of Physico-Chemical Parameters in Kisra Reservoir, NIFFR Estate, New Bussa, Niger State

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Abstract

The impact of human activities in and around reservoir is felt on the unique physico-chemical properties of water on which the sustenance of fish that inhabit the reservoir is built, as well as to the functions of the reservoir. Seasonal comparative study on some aspect of physico-chemical parameters of kisra reservoir was conducted from June 2020- February 2021. The water samples were collected once in a month using water sampling bottles. Water temperature was collected *in-situ*. The other parameters were analyzed using standard analytical techniques. The result showed that some parameters like; DO, BOD, turbidity and depth were higher in wet season than in dry season, while conductivity, water temperature, alkalinity and pH were higher in dry season than in wet season. Although, most of all these parameters fall within the recommended range value, the water was found to be of good quality for fish culture and some parameters vary between the two seasons.

Keywords: Physico-chemical Parameters, Season, Kisra, Reservoir

Introduction

Water quality is an ongoing challenge facing developing countries in the whole world. Water as an important natural resource that influences human settlement patterns, agricultural activities and citing of industries (Nwaugo *at al.* 2006). Water monitoring in ponds, lake and reservoirs is the daily observation and analysis of water parameters to ensure provisional water quality and quantity by adopting good water quality management strategies and as well ensure its supply in adequacy through the appropriate channels of flow as well it acceptability for fish culture. Fishes are predisposed to diseases and other problems due to poor water quality in ponds and reservoirs and daily water monitoring in reservoirs is a panacea to many fish problems. Thus, water qualities parameters differ from season to season; it then becomes very important to study our lakes, reservoirs throughout the year. The aim of this study is to check whether the reservoir is good for fish culture through the use of physical and chemical parameters and to check on how these parameters behave across the season (Wet and Dry).

Materials and Method

Study Area

The study area was kisra reservoir located within the kainji lake region at NIFFR estate, along Hatchery, New Bussa, Niger State. The reservoir was constructed in 2008. It is located at latitude of N9°52'44" and a longitude of E4°32'23". Its rainy season period is from April\May to October and a dry season from November to March.

Sampling

The sampling was carried out once in a month (from June 2020 to February 2021). The samples were collected in the morning using water sampling bottle between 09:30am to 10:30am and the samples were all analyzed within 24hrs after collection. The experiment was carried out at limnology laboratory in National Institute for freshwater fisheries research (NIFFR), New Bussa, Niger State.

The instruments/methods used in evaluation of the parameters are as follows:

Table 1: The instruments/methods employed in this study

Parameter	Methodology
pH	pH Meter
Transparency	Secchi disc
Water temperature	Thermometer
Conductivity	Conductivity Meter

Alkalinity	Titration
DO	Azide Modification
Depth	Secchi disc

Results

The results of water quality obtained in this study and compared to the recommended range values are presented in Table 2. All the parameters under consideration were within the recommended range value. The performance of some physico-chemical parameters in wet and dry season is shown in Figure 1. The results indicated that the values of conductivity, alkalinity and temperature were higher in dry season, while DO and BOD were higher in wet season months. However, pH were within the same range.

Table 2: Summary of Results of Water Quality Compared to the Recommended Range value

Parameters	Wet Season	Dry Season	Recommended Range Value
pH	7.1	7.2	6.5-8.8 Boyd (1979)
Colour	YG	B	
Conduc. ($\mu\text{S}/\text{cm}$)	54	67.7	150-500 $\mu\text{S}/\text{cm}$ Russell et al (2011)
Alkalinity (Mg/l)	10	29.2	5-500Mg/l Lawson, (1995)
Depth (M)	1.13	0.40	
Water temp. ($^{\circ}\text{C}$)	28.8	29.6	27.6 $^{\circ}\text{C}$ -30 $^{\circ}\text{C}$ FAO (2006)
Turbidity (M)	0.38	0.16	
D.O (Mg/l)	14	5.80	5-8Mg/l Swingle (1969)
B.O.D (Mg/l)	5.20	4.30	3-20Mg/l Boyd (2003)

Conduc.- Conductivity Temp.- Temperature D.O- Dissolve Oxygen B.O.D- Biological Dissolve Oxygen, YG- Yellow-green B- Brown

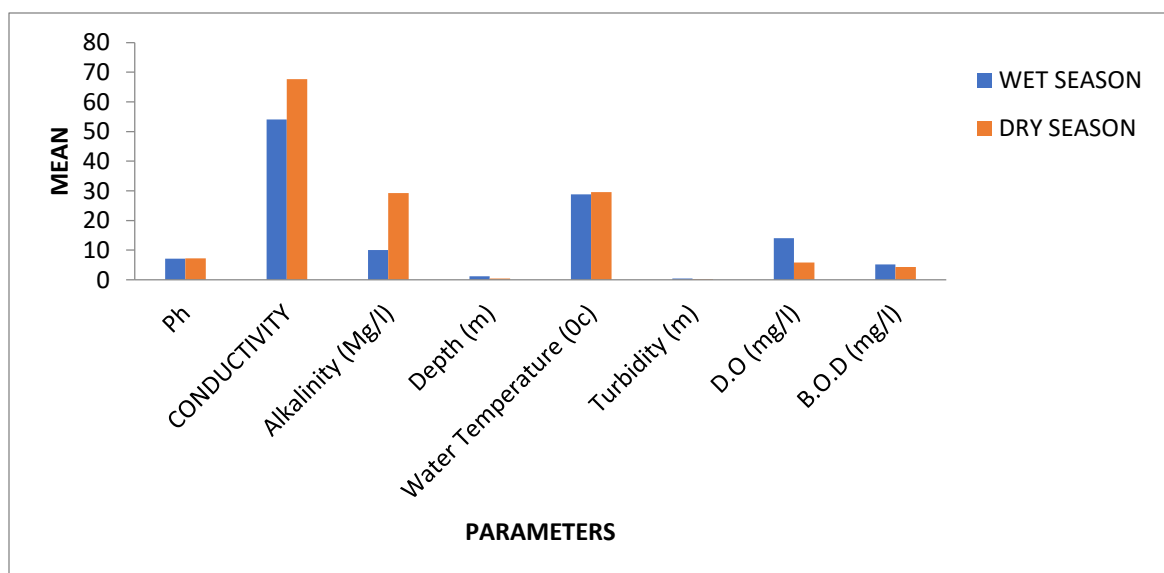


Fig 1: Graph showing the performance of some physic-chemical parameters in wet and Dry Season

Discussion

The pH mean value of the reservoir varies slightly in wet and dry season. The value of 7.2 was obtained in dry season and 7.1 were obtained in wet season. Although all these value fall within the recommended range value as

prescribed by Boyd (1979) of 6.5-8.8. The slight difference in pH is attributed to as a result of increase in algae populations by their photosynthetic activity during the dry season. Colour of the kisra reservoir in wet season was found to be yellow green while in dry season was found to be Brownish. The brownish colour of the reservoir in dry season was as a result of too much dust from the harmattan weather condition, increase in human and animal activities around the reservoir and little or no rain or flood water coming into the reservoir. The yellow green colour in the wet season was as a result of more water settling into the reservoir and little human and animal activities.

The conductivity mean value of wet season (54 μ s/cm) of kisra reservoir was lower than dry season (67.7 μ s/cm) of the reservoir. This implies that the conductivity is higher in dry season than in wet season; this could be as a result of more evaporation taking place in dry season than in wet season also due to dilution of more salt in wet season than in dry season where the water level is low when compared to the wet season. The Alkalinity of wet season (10mg/l) is lower than that of dry season (29.2mg/l); though fall within the permissible limit of 5-500mg/l as recommended by Lawson (1995). This is due to dilution factor in the wet season i.e more water is in the reservoir to dilute salt concentration which is less during the dry season and at such results to low alkalinity in the wet season.

The depth of the reservoir was deeper in wet season than in dry season. The wet season value was 1.13m when compared to the value obtained in dry season of 0.40m. This is due to the fact that, in rainy season more water flows into the reservoir whereas in dry season little or no water flows into the reservoir and evaporation rate is high at dry season than in wet season which result to low depth in dry season. The mean water temperature of the reservoir for wet season and dry season was found to be 28.8°C and 29.6°C respectively. This value falls within the recommended range value of 27.6-30°C by FAO (2003). The seasonal variation in temperature in kisra reservoir showed that water temperature was higher at dry season than in wet season, the low temperature in wet season could be as a result of cool weather condition and high humidity which result to low evaporation effect. Turbidity obtained in this study shows that, the water has higher turbidity in wet season (0.38) than in dry season (0.16m). The reason for this wide difference is as a result of presence of high rain water, surface run offs, the settling effects of the suspended materials and less human and animal activities around the reservoir. The low turbidity observed during the dry season maybe as a result of no rain water available or low flow of flood water into the reservoir.

Dissolve oxygen (D.O) of the reservoir in wet season (14mg/l) is relatively higher than that of dry season (5.80mg/l). The reason for this difference is attributed to temperature. The cooler the temperature to higher the dissolve oxygen and vice versa. In this study the water temperature in wet reason is cooler than the water temperature in dry season and this could be the reason for the difference in dissolve oxygen in the reservoir. Also dirty materials which hinder dissolve oxygen availability were less in wet season when compared to the dry season.

Biological Oxygen Demand (B.O.D) of kisra reservoir in wet season (5.20mg/l) was found to be higher than dry season (4.30mg/l). Both the values for wet season and dry season fall within the permissible range of 3-20mg/l as recommended by Boyd (2003).

Conclusion

At the end of the study, it was found out that the water quality of kisra reservoir is of high quality and good for fish culture. It was also learnt that some of these physical and chemical parameters differs from wet season to dry season like; D.O, B.O.D, turbidity, depth are all higher in wet season than dry season while conductivity, water temperature, alkalinity and pH are all higher in dry season.

References

- Boyd, C.E. and Lichtkoppler, F. (1979). Water quality management in pond fish culture. International center for aquaculture, Agric Expt. Station Auburn University Alabama.
- Boyd, C.E. (2003). Guide lines for aquaculture effluent management at farm-level. *Aquaculture*;226:101112.
- FAO (Food and Agriculture Organization of the United Nations). (2006). State of World Aquaculture. (2006). FAO Fisheries Technical paper 500. Rome: FAO Fisheries Department.
- Lawson, T.B. (1995). Fundamentals of aquaculture engineering. New York, Chapman and Hall.
- Nwaugo, V.O., Obiekezie, S.O., Onyeagba, R.A., Okereke, J.N. and Udebuani, A. (2006). The physicochemical investigation of Amicol Lake in Ivo area of Ebonyi State, Nigeria. *World Journal of Biotechnology*, 7: 1055-1061.

- Russell, M., Shuke, R. and Samantha, S. (2011). Effects of conductivity on survivorship and weight of Goldfish (*Carassius auratus*). Available at <http://departments.juniata.edu/biology/eco/documents/Russell et al. pdf>. 23 Apr (2017).
- Swingle, H.S. (1969). Method of analysis for waters, organic matter and pond bottom soils used in fisheries research. Auburn University, Auburn, Alabama. Alabama. Research and development;22(30).

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Bacteria Isolation from the Skin Of Sick Fish (*Deprane africana*) And It's Coastal Water Habitat

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Abstract

The importance of fish skin bacteria in aquaculture productivity and water habitat influence in furnishing those microbes cannot be overemphasized. This study was set to determine the culturable bacteria flora of *Drepane africana* and its water habitat in order to correlate their relationship. Fish sample was collected from artisanal fishermen at Oniru beach, Victoria Island Lagos. Traditional spread plate method was used to isolate and enumerate total viable bacteria, total coli forms, *Vibriosp* and bioluminescent bacteria in appropriate growth media. All the bacteria groups were present in both the fish (*Drepane africana*) and the habitat water sample at varying degrees. Total vibrio count of 1.48×10^9 and 2.97×10^7 cfu ml⁻¹ were observed for *Drepane africana* and water sample respectively. You still did not include the total bacterial count? Total coli forms counts of 1.8×10^6 and 2.0×10^4 were observed for the fish (*Drepane africana*) and water respectively. The occurrence of bioluminescent bacteria (1.65×10^5 and 2×10^4) cfu ml⁻¹ were also found in *Deprane Africana* and water sample respectively. The bacterial load of the fish skin was generally more than that of the habitat water. The biochemical identification showed that *Proteus*, *Serratia* and *Citrobacter* were among the dominant culturable bacteria species from both the fish skin and water sample. The result of this study, gave a better knowledge of fish skin bacterial flora to enhance the use of microbial community for water quality monitoring, productive fish culture and ecological studies.

Keywords: Bacteria, Fish, Coastal environment, *Drepane Africana*

Introduction

Fish and fish products are a major source of protein for humans hence one of the most widely consumed sources of nutrient around the world. A huge percentages of the fish for human consumption are sourced from artisanal fishermen from lagoons, estuaries, and coastal waters which are the most affected by human activities. These fishes harbor microbes some of which are pathogenic to the humans. The pathogens; bacteria, fungi and virus are located on the gills, gut and skin of the fish, (Rani *et al* 2016). The Ocean is a heterogeneous environment where bacteria must adopt survival strategies like chemo tactic, movement, attachment and colonization of the nutrient rich fish skin (Stocker and Seymour 2012). Fish skin bacteria are very dynamic owing to the effect of the external water environment. Apart from protecting the internal environment of fish from leaking out substances like nutrients and solutes, into the external water environment, the skin of fish also secretes mucus that promotes the immunity of the fish against pathogenic bacteria and contains other antimicrobial compounds like peptides (Minitiet al 2017 (separate)).

Drepane africana otherwise known as sickle fish that is found mainly in the neritic zone. They live in groups feeding on eggs, benthic in vertebrates and detritus on sandy and muddy bottoms of about 40meter depth (Froese and Pauly 2021). The neritic zone in which *Deprane Africana* is found, are affected by human factors like eutrophication which leads to the abundance of bacteria and other microbes. This, including the species dependent factors, physicochemical parameters among others, is a major factor affecting bacteria occurrence on the skin of fish in a particular water environment Krotman *et al* (2020).

Materials and Methods

Fish samples collection: Samples of the marine / brackish water fish *Drepane africana*, from artisanal fishermen was bought from artisanal fishermen at Oniru Beach, Victoria Island Lagos {6°27'55.5192'N and 3°24'23.2128' E} in July 2019. The fish and habitat water samples were transferred into sterile containers and immediately transferred to Microbiology Laboratory at Nigeria institute for Oceanography and Marine Research for analysis.

Sample preparation: The fish was immersed in a beaker containing 50ml of sterile 3% NaCl solution. Fish was held in place with the help of forceps as it was gently scraped and rinsed in the NaCl solution, this served as stock solution. The stock solution was serially diluted for subsequent inoculation on the different growth media. The habitat water sample was equally diluted for inoculation on growth media

Isolation and enumeration of culturable bacteria: Aliquots (0.1ml) of appropriate dilutions were inoculated into specific agar plates for isolation and enumeration of the different groups of bacteria. The total viable bacteria were cultured using nutrient agar, thiosulphate-citrate-bile-sucrose agar (TCBS) was used for *Vibrio* sp., MacConkey agar for total coli form, while Boss medium (30g of NaCl; 0.888ml of glycerol; 10g of bacteriological peptone and 15g of Agar in 1L distilled water) was used for the culturing of luminescent bacteria. The plates were incubated at appropriate temperature for 18 to 24h and bacteria colonies were counted using Lapiz digital colony counter and expressed in colony forming units per ml of each fish stock solution.

Morphological and biochemical identification: Bacterial isolates on each growth media were randomly picked, purified on Tryptone soy agar and further presumptively identified based on their cellular morphology and biochemical characteristics according to the taxonomic scheme of Holt *et al.* (1994).

Enumeration of culturable bacteria: The total count of the different groups of culturable bacteria from the skin of *Depraneafricana* and water sample is shown in Table 1. The range of the population of all bacterial groups was between 2.0×10^4 and 1.4×10^9 cfum⁻¹ in favor of the fish skin which carried more bacteria load.

Morphological and biochemical identification: The results of the morphological and biochemical characterization of the culturable bacteria isolated from the marine fish skin and the habitat water presumptively identified them to belong to the following *Serratiasp*, *Citrobactersp*, *Vibriosp*, *Proteussp*, and *E. coli* as depicted in Table 2.

Table 1: Mean +SD Of Different Bacterial Groups On The Skin Of The Marine Two Fish Species

BACTERIALGROUPS	FISH SPECIE /WATER SAMPLE	
Drepaneaficana	Water	
Total viable bacteria count (cfum ⁻¹)	4.27×10^8	9.8×10^7
Total <i>Vibrio</i> sp. count (cfum ⁻¹)	1.48×10^9	3.555×10^7
Total coliform count (cfum ⁻¹)	1.8×10^6	2.0×10^4
Total luminescent bacteria count (cfum ⁻¹)	1.65×10^5	2.0×10^4

Table 2 Morphological and biochemical characteristics of bacteria from the marine fish skin and its Habitat water Morphological and Biochemical

CHARACTERISTICSISOLATES

NAF NAW TCBF TCBW MCF MCW BF BW

Shape

Gram reaction	-	-	-	-	-	-	-	-
Indole test	-	-	-	-	-	-	+	-
Glucose fermentation	+	-	-	+	-	-	-	-
Lactose fermentation	+	-	-	-	-	-	-	-
Citrate utilization	+	+	+	+	+	+	+	+
H ₂ S production	-	-	-	-	-	-	-	-
Gas production	-	-	-	-	-	-	-	-

Presumptive IDP. *spS. spS. spC. spE. spC. sp* *V:sp*

Key: -=negative, +=positive,, *Vsp Vibrio sp*, *S.sp Shigellasp*, *P.sp. Pseudomonas sp.*, *C.sp Citrobacter sp*.

All bacteria groups isolated in this study occurred more in the sickle fish sample than in the habitat water with *Vibrio* species showing the widest margin of 1.48×10^9 and 3.555×10^7 . Luminescent bacteria had the closest margin of occurrence in the fish and water sample, 1.65×10^5 and 2.0×10^4 , showing that luminescent bacteria occurs freely in marine water and in symbiotic association with fish, (Zarubiet *al*, 2011). This also allows that many species and strains of the *Vibrio spp.* are not luminescent, Zhou *et al*, (2012), considering the *Vibrio spp.* isolation of 1.48×10^9 and 3.555×10^7 in the fish and habitat water respectively. All isolated bacteria groups are gram negative, (Ayaz and

Choi, 2014), maintains that gram-negative bacteria proliferate easily even in harsh marine environments because of the structural diversity of the cell wall and its components, particularly the lipopolysaccharides (LPS).

Conclusion

The importance of skin microbiota in the adaptation and survival of its host cannot be over emphasized; therefore this study serves as a fundamental base for better understanding of some of the specific bacteria shared by sickle fish and its coastal environment. *Drepaneafricana* is one of the common fishes of the tropical coasts, the understanding of the bacteria of its skin and habitat water would be a good reference point in further studies and understanding skin bacteria of other fish species of the same environment.

References

- Agut J. O. and Agwu O. A. (2019). Enumeration and Biochemical Identification of the Skin Bacterial Flora of Two Marine Fishes. Agric Society of Nigeria, 2019 Conference.
- Ayaz M., and Choi S (2014). Gram-Negative Marine Bacteria: Structural Features of Lipopolysaccharides and Their Relivance for Economically Important Diseases. 12(5);2485-2514
- Ayaz, A., &Karataş, S. (2010). Dominant aerobic bacterial community of sea bass (*Dicentrarchuslabrax* L. 1758) larvae during weaning from *Artemia* to dry feed in culture conditions. *Turk. J. Vet. Anim. Sci.*, 34(6), 501–506. <https://doi.org/10.3906/vet-0805-24>
- Badar, U., Shoeb, E., Daredia, K., Akhtar, J., & Ansari, M. A. (2012).Screening and Characterization of Luminescent Bacterial Strain.*Journal of Basic & Applied Sciences*, 8, 602–606.
- Bentzon-Tilia, M., Sonnenschein, E. C., and Gram, L. (2016) Monitoring and managing microbes in aquaculture – towards a sustainable industry.*MicrobBiotechnol* 9: 576–584.
- Bruijn, I. De, Liu, Y., Wiegertjes, G. F., & Raaijmakers, J. M. (2018).Exploring fish microbial communities to mitigate emerging diseases in aquaculture. *FEMS Microbiology Ecology*, 4, 1–12. <https://doi.org/10.1093/femsec/fix161>
- Froese R. and Pauly D. Editors (2021) Fish Base Worldwide web electronic publication. [www.fishbase.org\(06/2021\)](http://www.fishbase.org(06/2021)).
- Holt, J. G., Krieg, N. R., Sneath, P. H. A., Stanley, J. T., and William, S. T. (1994). Bergey’s Manual of Determinative Bacteriology. Baltimore: Williams & Wilkins.
- Krotman Y; Yergaliyev T, M; Szitnenberg A; (2020) Dissecting the factors shaping fish skin microbes in a heterogenous inland water system. *Mmicrobiome* 8(9) Doi: 10.581 Zenodo 3583001.
- Minniti G., Hagen L. H., Porcellato D., Jorgensen S.M., Pope P. B., and Kolstad G. V. (2017) The skin mucus Microbial Community of Farmed Atlantic Salmon (*SalmoSalae*). *Frontiers in Microbiology*, 8, 1-3.
- Nagvenkar, G. S.; Nagvenkar, S.S. Rivonker, C U; Sangodkar, U. M. X. (2014).Microbial diversity and enzyme production in mullet *Mugilcephalus* L. (Pisces) along Goa, west coast of India. *Indian Journal of Marine Sciences*, 35(1), 36–42.
- Rani M. K., Gheladurai G., and Jayanthi G (2016). Isolation and Identification of bacteria from marine Market Fish *Scromberomorousguttatus*, Bloch and Schneider (1801) from Madurai District, Tamil Nadu, India. *Journal of parasitic disease* 40(3):1062 Doi://10.1007/s12639-014-0634-o.
- Stocker R. and Seymour J. R. (2012). Ecology and physics of bacteria chemotaxis in the ocean. *Microbiolmoi Biol.*2012, 76(4)798-812 Doi: 10,1128 / MMBR.ooo29-12.
- Zarubi M, Belkinc S,Ionescuc M, andGenin A (2011). Bacteria Luminecence as a Lure for Marine Zooplankton and Fish.www.pnas.org/cgi/doi/10.1073/pnas.1116683109
- Zhou J, Fang W, Yang X, Zhou S, Hu L, Li X, et al. (2012) A Nonluminescent and Highly Virulent *Vibrio harveyi* Strain Is Associated with “Bacterial White Tail Disease” of *Litopenaeusvannamei* Shrimp. *PLoS ONE* 7(2): e29961. <https://doi.org/10.1371/journal.pone.0029961>

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Digestive Enzymes and Gut Morphometry of African Carp (*Labeo ogunensis*) in Asejire Lake Ibadan, Oyo State, Nigeria

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Abstract

Studies on the digestive enzymes and gut morphology at each life stage is key to formulation of artificial feed and efficient feed conversion and consequently profitability. This study therefore investigates the gut morphometry and the digestive enzymes of different size groups of *Labeo ogunensis* in Asejire Lake. The size groups obtained are: 15cm – 23cm (small) and 24cm - 33cm (big). Digestive enzymes were determined and measured following standard procedures while morphometric characters of the gut were taken using standard metre rule and weigh balance. The lipase activity was highest of all the digestive enzymes in both seasons. Amylase, pepsin and lipase mean value in wet and dry season are (1.07 ± 1.35 and 0.77 ± 1.07); (1.04 ± 0.87 and 0.26 ± 0.36); (41.46 ± 17.83 and 28.76 ± 15.34), respectively. Gut morphometric parameters the relative gut length and the relative gut weight were higher in female (7.95 ± 0.69 , 0.049 ± 0.007 , 1.189 ± 0.247) than male (7.934 ± 0.38 , 0.047 ± 0.003 , 0.974 ± 0.160) but with no significant differences ($p > 0.05$) in both sexes. Seasonal changes do not have any effect on the gut morphometry.

Keywords: Gut Morphometry, Digestive Enzymes, Length and Weight, Nutrient.

Introduction

Growth, health and reproduction of fish and other aquatic animals are primarily dependent on an adequate supply of nutrient, both in terms of quantity and quality, irrespective of the culture system in which they are grown (Hasan, 2001). The ability of any species of fish to digest and utilize any diet consumed depends on the appropriate digestive enzymes present. Digestion in fish is not only associated with the type of nutrients but also depends on the feeding habit of the fish. Hence determining digestive enzyme and gut morphometry is potential interest to obtain valid information concerning fish digestive physiology (Hani *et al.*, 2018). There is scarce information on the gut morphology and digestive enzymes of *Labeo ogunensis* thus this study reports the digestive enzymes and gut morphometry of *L. ogunensis* from Asejire Lake, to enhance effective management of this species and provide baseline information for further investigative researches required to formulate suitable feeds, improve growth rate, better fish carcass quality and also practise effective feeding management for easy culture of *L. ogunensis*. The aim of this study is to document the gut morphometry and digestive enzyme in different sizes of male and female of *Labeo ogunensis* in Asejire Lake, to determine the seasonal changes in gut morphometry and digestive enzyme of varied sizes and sexes of *Labeo ogunensis* in Asejire Lake and to determine the relationship between the gut morphometry, sizes and sexes of *Labeo ogunensis* in Asejire Lake.

Materials and Methods

Asejire lake is the study area, it is one of the series of West African Rivers (Omoike, 2004). Its entire length is 19.5 km, catchment area above the dam is about 7,800 km² and the impounded area is 2,342 hectares. Fresh samples of the *Labeo ogunensis* were collected monthly from fishermen of the Asejire for wet season (August to October) and dry season (November to December). The samples were collected inside ice in container, transported to the Laboratory of Department of Veterinary Medicine, University of Ibadan and kept in the deep freezer for subsequent examination, different sizes in catches were collected and grouped into two sizes based on their total length, the big sizes ranges are 24-33cm while the small sizes 15-23cm.

Fish samples were identified to species level following the field guide of Nigerian freshwater fishes by Olaosebikan and Raji (2013). Length and weight measurement were carried out using Jisr *et al.*, (2018). Gut length and weight measurements were prepared and carried out using Jisr *et al.*, (2018). All gut parameters were calculated according to German and Horn (2006). Digestive enzymes were determined using standard methods, Benedict's qualitative reagents were used for the qualitative assay of glycosidases (carbohydrates) following the methods of Olatunde *et al.*,

(1988) while the quantitative assays were conducted using the methods described by Plummer (1978). The qualitative determination of proteases was carried out based on the method of Balogun and Fisher (1970) while the quantitative methods were following Herriott (1955), the qualitative and quantitative activity of lipases were determined using Ogunbiyi and Okon (1976).

Data were analysed using descriptive statistics such as mean, standard deviation, bar chart were used. Inferential statistics like one way analysis of variance (ANOVA), Pearson correlation were also used. Significance was accepted at $p < 0.05$.

Results and Discussion

Fish growth is determined through the combined effects of food quality and quantity; and the dietary habits of fishes are essential in determining its diet with respect to age, size, life history stages, season, time of day as well as locality in which they occur. Table 4 shows digestive enzymes has higher mean value in big size fish than in small size fish according to Choudhary *et al.*, (2014) length of the gut of fish largely depends on upon the feeding behaviour of a particular fish while the relative gut weight (RGW) is usually addressed to evaluate the amount of tissue dedicated by fish to their digestive tract and increasing gut mass is one of the mechanisms used by animals to increase energy intake from food which shows why the big size fish has more digestive enzymes mean quantity value.

The results in Table 1 shows low level of amylase and maltase in both seasons is in agreement with Fagbenro and Adedire (2001) which implies that fish with low value of carbohydrate enzymes show the inability of fish to utilize carbohydrate food components as dietary energy source. The result shows that lipase has the highest value in all the digestive enzymes value in both seasons this means the fish consume fat rich food according to Tramiet *et al.*, (2005). Prey fish or insects as stated by Fagbenro and Adedire (2001) are probably the most important source of dietary lipids which represents the utilization of poly-unsaturated fatty acids as the energy source. The fish has more algae, detritus and phytoplankton to feed on since they are bottom deposit feeder and the result shows that higher digestive activities were found in the wet season than dry season, this is in agreement with Naziya and Shaikh (2017).

Variation in seasons in the gut morphometric parameters can be due to change in temperature which in turn influence consumption and rate of digestion and also quality and quantity of available growth. According to feeding guilds reported by Al-Hussaini (1994), fish are recognized as carnivores, omnivores or herbivores, when RGL ranges respectively between (0.6–2.4), (1.3–4.2) and (3.7–6.0) this negates the result of this study as our RGL ranges from 7.804 ± 0.715 and 8.045 ± 0.57 in dry and wet season respectively and 7.93 ± 0.38 and 7.95 ± 0.69 in male and female respectively. According to ZI values, Kramer and Bryant (1995) also categorized fish feeding habit based on various Zihler Index range; such as carnivorous (ZI = 2.3–3.2), omnivorous (ZI = 2.4–5.8) or herbivorous (ZI = 11.6–55.0).

In our study the ZI values ranged between 2.812 ± 0.239 to 2.86 ± 0.27 in dry and wet season respectively while it ranged from 2.99 ± 0.243 and 2.74 ± 0.36 in the male and female respectively, which indicates that *L. ogunesis* can be carnivorous or omnivorous is in agreement with Kramer and Bryant (1995) ZI of carnivores and omnivores in the two seasons. The Condition factor is a term used to compare the condition of fatness or well-being of the fish, from the result we have it shows the fish sampled is in good condition at the time of sampling by Shinkafiet *et al.*, (2013) standard.

Table 1: Comparison of digestive enzyme of *Labeo gunensis* in wet and dry seasons

Wet Enzymes	Dry	Mean $\pm$ SD	Mean $\pm$ SD	p-value
α -amylase		1.07 ± 1.35	0.77 ± 1.07	0.77
Glycosidase	Sucrase	0.59 ± 0.64	0.14 ± 0.18	0.01
Maltase		0.52 ± 0.6	0.10 ± 0.07	0.14
Proteases	Chymotrypsin	1.22 ± 1.23	0.29 ± 0.44	0.00
Pepsin		1.04 ± 0.87	0.26 ± 0.36	0.00
Lipases	Lipase	41.46 ± 17.83	28.76 ± 15.34	0.02

Table 3: Comparison of gut morphometry parameters of *L.ogunensis* with condition factor (K) of both male and female in wet and dry seasons

Mean±SD Pearson	Dry	Wet	correlation	p-value
RGL	7.804±0.715	8.045±0.57	0.46	0.18
RGW	0.047±0.004	0.044±0.007	-0.27	0.42
ZI	2.812±0.239	2.86±0.27	-0.19	0.68
F	1.063±0.24	1.117±0.228	0.26	0.26

RGL- Relative gut length, RGW- Relative gut weight, ZI- Zihler index, K- Fulton's condition factor.

Table 4a: Digestive enzymes big and small sizes of *Labeoogunesis* in dry season

		Big	Small
Enzymes			
	α-amylase	1.32±2.69	0.50±0.84
Glycosidase	Sucrase	0.20±0.28	0.082±0.08
	Maltase	0.09±0.06	0.114±0.08
Proteases	Chymotrypsin	0.388±0.58	0.201±0.3
	Pepsin	0.313±0.25	0.20±0.46
Lipases	Lipases	30.78±14.68	26.74±15.99

Table 4b: Digestive enzymes big and small sizes of *Labeoogunesis* in wet season

		Big	Small
Enzymes			
	α-amylase	1.23±1.52	0.93±1.17
Glycosidase	Sucrase	0.63±0.70	0.55±0.58
	Maltase	0.71±0.79	0.327±0.45
Proteases	Chymotrypsin	1.175±1.4	1.25±1.32
	Pepsin	1.11±0.79	0.96±0.93
Lipases	Lipases	45.39±15.68	37.53±19.99

Conclusion and Recommendation

Labeoogunesis are specialized feeding on algae and detritus from the substratum, which shows that the fish is bottom deposit feeder. Further studies on the gut morphology of this fish species should be carried out for a longer period of time and on other water bodies.

References

- Al-Hussaini A. H.(1949). On the Functional Morphology of the Alimentary Tract of Some Fish in Relation to Differences in their Feeding Habits: Anatomy and Histology. *Quarterly Journal of Microscopical Science*. s3-90(10):109–39. 41.
- Choudhary, S., Kumar, U., and Kumar U. 2014. Study of morphohistology of alimentary canal in relation to feeding behavior of *Channa punctatus* from the wetlands (Chaur) of Begusarai District N. Bihar India. *International Journal of Scientific Research* 3.8: 2277-8160.
- Food and Agriculture Organisation 2016. The state of world fisheries and aquaculture 2016. Fisheries Department Rome from www.fao.org.
- Hani Y. M. I., Marchand A.;Turies C.;Kerambrun E.;Palluel O.;Bado-Nilles A., (2018) Digestive enzymes and gut morphometric parameters of threespine stickleback (*Gasterosteus aculeatus*): Influence of body size and temperature. *PLoS ONE* 13(4): e0194932. [https://doi.org/ 10.1371/journal.pone.0194932](https://doi.org/10.1371/journal.pone.0194932)
- Hasan, M.R. 2001. Nutrition and feeding for sustainable aquaculture development in the third millennium. *Aquaculture in the Third Millenium*. In:Subasinghe, R.P. *et al.*, Eds. Technical Proceedings of the Conference on Aquaculture in the Third Millenium, Bangkok, Thailanf,, 20-25 February 2000. 193-219
- Jisr N., Younes G. ,Sukhn C., El-Dakdouki M. 2018. Length-weight relationships and relative condition factor of fish inhabiting the marine area of the Eastern Mediterranean city, Tripoli-Lebanon. *Egyptian Journal of Aquatic Research* 44 (2018) 299–305
- Kramer D. L., Bryant M.J. (1995). Intestine length in the fishes of a tropical stream: 2. Relationships to diet—the long and short of a convoluted issue. *Environmental Biology of Fishes*. 42(2):129–41
- Olaosebikan, B.D. and Raji A. 2013. Field Guide to Nigerian Freshwater Fishes (Revised Edition).National Institute of Freshwater Fisheries Research (NIFFR), New Bussa, Nigeria. FCFFT, P.M.B. 1500, New-Bussa Niger State, Nigeria. Decency Enterprises and Stationeries Ltd.
- Olatunde, A. A., Ukoha, A. I. and Oguntayo, B. F. 1988. Digestive enzymes in the alimentary tract of *Clariaslazera* (Cuvier and Valenciennes) Family Clariidae (Osteichthys: Siluriformes). *Achiv fur Hydrobiologies*, 112:107 – 113.
- Omoike, A. 2004. Sustainable Management of Fisheries of Asejire Reservoir and its Environs in Southwestern Nigeria. Ph.D. thesis, Department of Wildlife and Fisheries Management, University of Ibadan, Ibadan, Nigeria. pp186.
- Naziya P. and Shaikh N. (2017). *Global Journal of Science Frontier Research: C Biological Science* Volume 17 Issue 2 Version 1.0pg 13-16
- Plummer, D. T. 1978. An introduction to practical biochemistry, 2ndedition. McGraw Hill Book Co., London. pp 283.
- Shinkafi, B.A., Ukoha, L.N., and Tukur N.A 2013. Some Aspects of Growth and Reproduction in the Nile Perch (*Lates niloticus*, Linne 1762) from River Rima, North-western Nigeria. *Nigerian Journal of Fisheries and Aquaculture* 1: 31-41.
- Tramati, C., Savona, B. and Mazzola A. 2005. A study of the pattern of digestive enzymes in *Diploduspuntazzo*(Cetti 1777) (Osteichthyes, Sparidae): evidence for the definition of nutritional protocols. *Aquaculture international* 13: 89-95.
- Zihler, F. 1981 Gross Morphology and Configuration of Digestive Tracts of Cichlidae (Teleostei, Perciformes): Phylogenetic and Functional, Significance. *Netherlands Journal of Zoology*32.4: 544–71.

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Morphometric Characteristics, Length-Weight Relationship And Condition Factor Of Three Commonly Consumed Fish Species From Mashigi Dam, Kankara Katsina State

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Abstract

Morphometric characteristics, Length-weight relationship and Condition factor of three most commonly consumed fish species *Bagrus bayad*, *Oreochromis niloticus* and *Clarius gariepinus* from Mashigi dam, Kankara, Katsina State were studied using standard procedures. The fish species for this study were sampled from fishermen at Mashigi dam, Kankara from June- August 2021. One hundred and twenty (120) fishes consisting of 40 from each species (*B. bayad*, *O. niloticus* and *C. gariepinus*) were purchased and collected randomly from the local fishermen. Morphometric measurements were taken and analysed for LWR relationship and Fulton's Condition Factor. The results showed that all the species exhibited negative allometric growth (b- 0.22-141). Fulton's K value of 1.34 and 3.4 indicated that *B. bayad* and *O. niloticus* were of good condition during the study period. lowest condition factor was observed for *C. gariepinus*. The species (*C. gariepinus*) was observed to have the highest total length of 34.43 ± 2.26 cm followed by *B. bayad* with 26.65 ± 3.29 cm and *O. niloticus* has the lowest total length of 18.62 ± 1.23 cm. There were no significant differences ($p > 0.05$) in Head Length between *B. bayad* and *O. niloticus*. However, there were significant differences in Total Length among the three fish species. There is the need to enhance efficient management system to enhance fish productivity in the dam.

Key words: Morphometric, Length-Weight relationship, Condition factor, Mashigi dam, *Bagrus bayad*.

Introduction

Morphometric differences among stocks of a fish species are recognized as important for evaluating the population structure and as a basis for identifying stocks (Turan, 2004). Morphometric measurements are widely used to identify differences between fish populations (Cheng *et al.*, 2005). The field of fishery science has employed many tools such as genetics and morphometric to differentiate fish population (Mir, *et al.*, 2013). Morphometric analysis plays an important role to estimate relationship between various parts of body (Carpenter *et al.* 1996).

Length-weight relationship of fish is widely recognized as an important tool in fisheries science especially in ecology population dynamic and stock management (Abdoli and Rasooli, 2008). LW measurements in conjunction with age data can give information on the fish stock, age maturity, life span, mortality, growth and reproduction (Kumar *et al.*, 2014). Understanding the weight-length relationship is of paramount importance in fishery resource management and useful in comparing life history and morphological aspects of populations inhabiting in different regions (Karna *et al.*, 2012). Furthermore, this relationship is used to ascertain the condition of fish and to determine whether the growth pattern is isometric or allometric.

Condition factor is an index reflecting interaction between biotic and abiotic factors in the physiological conditions of fishes and is found by relating the length of fish with the weight (Beyer 1987). It is used to compare the "condition", i.e., fatness or wellbeing of fish (Seher and Suleyman, 2012). Gomiero and Braga (2005) described the condition factor as an indicator of fish welfare in their habitat. The condition factor is based on the hypothesis that heavier fish of a particular length are in a better physiological condition. Yadau (2002) pointed out that higher value of K (> 1.0) always indicate well being of the fish and lower value of K (< 1.0) reflect disease condition, over population, scarcity of suitable food or seasonal variations.

Bagrus bayad, *Oreochromis niloticus* and *Clarius gariepinus* are commercially important fishes available throughout the season in the area and are highly patronized by the people of (Mashigi, Kankara) which might be due to their abundance palatability and good taste.

Morphometric characteristics, length-weight relationship and condition factor of fresh water fishes has been widely documented for instance; Abdulkarim and Jabir 2013; DanKishiya 2013; Yakubu and Okensebur 2011; Fagbuoro

2015; Mzungu *et al.*, 2017. However, there are no documented works on these three important commercial fishes from Mashigi dam, Kankara Katsina State which form the basis of this study.

The objective of this study was to generate current information on the morphometric characteristics, length weight relationship and condition factor of *Bagrus bayad*, *Oreochromis niloticus* and *Clarius gariepinus* from Mashigi dam, Kankara Katsina State.

Materials and Methods

Study Area

Mashigi dam is located in Kankara Local Government Area of Katsina State and located between latitude 11.79° 28'' and longitude 7.61° 68'' of the Equator. The dam was constructed in 1978 primarily for the supply of potable drinking water and domestic uses. The secondary purpose of the dam was fish production and irrigation. The dam has a surface area of 115 hectares at low water level with a maximum depth of 2.3m (Ibrahim, 2019)

Sampling and Fish Identification

The fish species for this study were sampled from fishermen at Mashigi dam, Kankara from June- August 2021. One hundred and twenty (120) fishes consisting of 40 from each species (*B. bayad*, *O. niloticus* and *C. gariepinus*) were purchased and collected randomly from the local fishermen. The fish samples were transported in an ice-packed plastic container in order to keep them fresh immediately to the Biology department laboratory at Umaru Musa Yar'adua University Katsina (UMYUK). In the laboratory, the fish samples were sorted out and identified to species level using the field guide key by Olaosebikan and Raji (1998).

Morphometry Measurements

The measurable morphometric characters used were standard length (SL), Body weight (BWT), Total Body Length (TL), Head Length (HL), Body width (BW). Predorsal Peduncle (PL), Caudal peduncle length (CPL) were taken along the body axis. The body weight (BWT) was measured using a weighing meter and recorded in grams (g). The total body length (TL), was taken along the anterior- posterior body axis from mouth tip to the end of the caudal fin. The dorsal fin length was taken from the start of the fin to the end by the dorsal side. The caudal fin length was taken from the caudal region to the end of the fin. The head length was taken from the tip of the mouth to the beginning of the operculum, while the body width was taken from the head region to the end of the caudal fin. All length measurement were recorded in centimetre (cm) and were taken using measuring meters.

Length weight relationship (LWR)

The statistical relationships between these two parameters were established by using equation developed by Froese, (2006)

$$W = aL^b$$

Where, W = Weight of fish (g)

L = length of fish in cm

a = constant, b = (slope) exponential expressing the relationship between length and weight.

The relationship ($W = aL^b$) when converted into the logarithmic form gives a straight line relationship graphically as: $\text{Log}W = \text{Log} a + b \text{Log} L$

Where, b= slope, Log a= constant.

Fulton's condition factor (k)-The coefficient of condition K was calculated using Fulton's (1904) formula as follow:

$$K = \frac{W \times 100}{L^3}$$

Where, W= weight of the fish in gram, L = length of the fish in cm, 100 = is a factor to bring the value of K near unity.

Data Analysis

The results obtained from the study were subjected to descriptive statistics, correlation and regression analyses using Graph pad Prism version 7.0 The raw data for the body weight and standard length were transformed to log of base 10 to normalized them and stabilize the variance. All the analyses were conducted at confidence level of 0.05.

Results

Curvilinear length-weight Relationships-

Table 1 shows the LWR and condition factor of the three fish species from Mashigi dam, Kankara, Katsina State. The 'b' values of 1.41, 0.16 and 0.22 were recorded for *B. bayad*, *O. niloticus* and *C. gariepinus* respectively all showing negative allometric growth. Fulton's K value 1.34 and 3.4 indicated that *B. bayad* and *O. niloticus* were of good condition during the study period. The coefficients of determinations (r^2) for the *B. bayad* and *O. niloticus* were 0.57 and 0.50 respectively. These reflect that 57% and 50% of the variation in the variables measured in this study could be explained by the analytical models adopted.

Table 1: Length weight relationship and condition factor of three fish species from Mashigi dam, Kankara Katsina State.

Species	Mean length (cm)	Mean weight (g)	GT	K	b	a	r^2	r
<i>B. bayad</i>	22.04±2.79	144.0±37.9	NA	1.34	1.41	0.27	0.57	0.75
<i>O. niloticus</i>	15.43±0.92	125.6±29.03	NA	3.42	0.16	0.026	0.50	0.71
<i>C. gariepinus</i>	30.0±1.307	236.4±20.49	NA	0.85	0.22	0.32	0.01	0.10

GT- Growth type, K- Condition factor, b- Slope, a-intercept, R^2 - coefficient of determination NA- Negative allometric, r- regression value.

Table 2 shows the morphometric characteristics of the three fish species. *C. Gariepinus* was observed to have the highest total length of 34.43± 2.26cm followed by *B. bayad* with 26.65 ± 3.29cm and *O. niloticus* has the lowest total length of 18.62 ± 1.23 cm. Standard length (SL), head length (HL), and predorsal length (PL) were also observed to be highest in *C. gariepinus* with 30.3 ± 1.37cm, 8.18 ± 0.39cm, and 10.19 ± 3.57cm respectively. Body depth (BD) was highest in *O. niloticus* with 6.48 ± 0.58cm and *B. bayad* recorded lowest 4.32 ± 0.79 cm. There were no significant differences $p>0.05$ in HL between *B. bayad* and *O. niloticus*. There were significant differences in TL among the three fish species.

Table 2: Morphometric measurements (mean ± SD) for *Bagrus bayad*, *Oreochromis niloticus* and *Clarias gariepinus* from Mashigi dam, Kankara Katsina State.

Characters.	<i>B. bayad</i> .	<i>O. niloticus</i> .	<i>C. gariepinus</i>
Total length (TL)	26.65 ± 3.29 ^a	18.62 ± 1.23 ^b	34.43 ± 2.26 ^c
Standard length (SL)	22.04 ± 2.79 ^a	15.43 ± 0.99 ^b	30.3 ± 1.37 ^c
Head length (HL)	5.18 ± 0.87 ^a	5.23 ± 0.47 ^a	8.18 ± 0.39 ^b
Body depth (BD)	4.32 ± 0.79 ^a	6.48 ± 0.58 ^b	4.87 ± 0.45 ^c
Predorsal length (PL)	8.82 ± 0.69 ^a	5.86 ± 0.69 ^b	10.19 ± 3.57 ^c
Caudal peduncle length (CPL)	1.68 ± 0.35 ^a	1.78 ± 0.19 ^a	1.54 ± 0.28 ^b

Means + SD with same superscripts along the rows indicate NS at $p\leq 0.05$

Discussion

Length-weight relationship and condition factor have several applications on fish biology, physiology, ecology and fisheries assessment (Elliot *et al.*, 2015). The results of this study indicated negative allometric growth ($b<3.0$) in all the three fish species (*B. bayad*, *O. niloticus* and *C. gariepinus*). This means that the fish becomes thinner with increase in length. The result of this study is in line with the findings of Haruna (2005), Nyaku *et al.*, (2008) where negative allometric growth was observed for *O. niloticus*. It is also in agreement with the findings of Abdulkarim and Jabir (2013) who reported negative allometric growth in three fresh water fish species from Kwanar are dam, Rimi Katsina State. The findings of this study also concurred well with the findings of Getso *et al.*, (2017) who reported similar results on *O. niloticus* and *C. gariepinus* from Wudil River, Kano State. In addition, the results of this study also agreed with the findings of DanKishiya *et al.*, (2018) who studied LWR of *B. bayad* from Zobe dam, Katsina State. However, the results of this study was in disagreement with the findings of Nwabueze and Garba (2015) who reported positive allometric growth of *B. bayad* from River Adofi in Southern Nigeria.

Condition factor reflects well condition of the fishes in their environment. The results of this study indicated that *B. bayad* and *O. niloticus* were in good condition ($K > 1$) while *C. gariepinus* was in poor condition ($K < 1$). The finding of this study agreed with the findings of previous researchers such as Mahmoud *et al.*, (2011); Abdulkarim and Jabir (2013); Dankishiya (2013) , Dankishiya *et al.*, (2018) who reported ($K > 1$). The low condition factor reported in *C. gariepinus* was in line with the findings of Oluwusi-Peters *et al.*, (2015) who reported similar K value in Owena Reservoir Ondo State ,Getso *e t al.*, (2017) from Wudil River Kano State. The low Condition factor in *C. gariepinus* might be as a result of poor nutrients or feed available for the species, as it has carnivorous mode of feeding. It might also be as result of adverse environmental condition of the water, sex, season and stress. Perry *et al.* (1996) reported that fishes with a low condition factor are presumably believed to have experienced adverse physical environment or insufficient nutrition.

The morphometric data in the present study agreed with the findings of other researchers like Oluwusi-Peters *e t al.*, (2015); Azua *e t al.*, (2017) who reported differences in the morphometric characteristics of different species as well as correlations among different parameters of the species. The different sizes of the fishes may either be due to genetics or environment due to fishing pressure or environmental pollution.(Sikoki, *et al.*, 1998).

Conclusion

It can be concluded that all the fish species (*B. bayad*, *O. niloticus* and *C. gariepinus*) studied in Mashigi dam exhibited negative allometric growth and the well being of the fishes are appreciable and good with the exception of *C. gariepinus*. Furthermore, there were existences of morphometric differences among the fish species.

Recommendations

The study therefore recommends the following:

- i. There is the need to enhance efficient management system to enhance fish productivity in the dam
- ii. Further research is needed on the dam productivity and morphomeric study of different fish species in the dam
- iii. There is the need for more research on the possibility of trying *B. bayad* farming as it has appreciable length and weight which might make it a good candidate.

References

- Abdoli, A., Rasooli P. (2008). Length-weight relationship of 10 Species of fishes collected from Iranian fresh waters, *Journal of Applied Ichthyology*, 22, 156-157
- Abdulkarim, B. and Jabir, N.S. (2013). Length-weight relationship and condition factor of three fish species from Konar Are Dam, Rimi Local Government, Katsina State, Nigeria. *Biological and Environmental Sciences Journal for the Tropics*. 10 (3), 32-37.
- Azua, E.T., Akaahan T.J., Akogwu, S.A. (2017) Variation in the Morphometry Measurements of Two Tilapia Fish Species in Relation to Their Body Weight Obtained from Lower Benue River at Makurdi, Benue State Nigeria. *Fish Aquatic Journal* 8: 208. doi:10.4172/2150-3508.1000208
- Beyer, J.E. (1987) Computing the Mean Weight of Fish at a given Length Class, *fish bytes* 5: P. 11 – 13. 139.
- Carpenter, K.E., Sommer, H.J., Marcus, L.F. (1996). Converting truss interlandmark distances to Cartesian Coordinates *Advances in Morphometrics (Springer)*, 103-111
- Cheng, Q., Lu D., Ma., L. (2005) Morphological differences between close populations discernible by multivariate analysis: A case study of genus *Coilia* (Teleostei: Clupeiforms). *Aquatic Living Resources*, 18: 187-92.
- Dan-kishiya, A. S. (2013). Length-weight Relationship and Condition factor of five Fish species from a Tropical Water Supply Reservoir in Abuja, Nigeria. *American Journal of Research Communication.*, 1 (9), 175-187.
- Dan-kishiya, A. S., Bichi, A. H. and Nababa, A. S. (2018). Length-Weight Relationship and Condition Factor Of Silver Catfish (*Bagrus Bayad* Forskal, 1775) In Zobe Reservoir, Dutsinma Local Government Area, Katsina State, Nigeria. *FUDMA Journal of Sciences*.2 (1)
- Elliot, H. A., Daniel, N. A. and Francis, A. (2015). Determination of Morphometric Relationship and Condition Factors of Four Cichlids from Golinga Reservoir in Northern Region of Ghana. *Online Journal of Biological Sciences*, 15 (3): (3): 201.206
- Fagbuaro, O. (2015) Morphometric characteristics and meristic traits of Tilapia zilli from three major dams of South Western states, Nigeria. *Continental Journal of Biological Sciences* 8: 1-7.

- Froese, R. (2006). Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology*, 22, 241-253.
- Fulton, T. W. (1904). The Rate of Growth of Fishes. *Twenty-second Annual Reports*. Part III. Fisheries Board of Scotland, Edinburgh, pp. 141–241.
- Getso, B.U., Abdullahi, J.M. and Yola, I.A. (2017). Length- weight relationship and condition factor of *Clarias gariepinus* and *Oreochromis niloticus* of Wudil River, Kano, Nigeria. *Agro-Science*, 16 (1): 1-4.
- Gomiero, L.M. and Braga, F.M. (2005) The Condition Factor of Fishes from two River Basins in Sao Paulo State, South East of Brazil, *Act Sci. Maring* 27 (1):73:78.
- Ibrahim, B.U.(2019). Fish species Diversity in Northern Nigeria Major Water bodies. Ibrahim Badamasi Babangida University Lapai. *Inaugural Lecture*. Series 15. Pg27.
- Karna, S. K., Sahoo, D. K. and Panda, S. (2012). Length- Weight Relationship and Growth estimation of *Lates calcarifer* Bloch) in Chilika lagoon, India. *Bulletin of Environment, Pharmacology & Life Sciences*, 1(3): 61 – 66.
- Kumar D.B., Singh N.R., Bink D. and Devashish, K. (2014). Length-weight relationship of *Labeo rohita* and *Labeo gonius* (Hamilton-Buchanan) from Sone Beel, the biggest wetland of Assam. *Indian Journal of Environmental Research and Development* 8 (3)
- Mahmoud, W. F., Amin, A.M.M., Elboray, K.F., Ramadhan, A.M. and El-Halfawy, M.M.K.O. (2011). Reproductive biology and some observation on the age, growth, and management of *Tilapia zilli* (Gerv , 1848) from Lake Timsah,. *International Journal* 3, 15-25.
- Mir, J.I., Sarkar, U.K., Dwivedi A.K., Gusain, O.P., Jena, J.K. (2013) Stock structure analysis of *Labeorohita* (Hamilton, 1822) across the Ganga basin (India) using a truss network system. *Journal of Applied Ichthyology* 29: 1097 -1103.
- Mzungu, I., Orpin, J. B. and Amos, B. (2017). The length- weight relationship and Condition factor of *Schilbe mystus* and Physico chemistry of water in Zobe Dam, Dutsinma, Katsina state. *FUDMA Journal of Science (FJS)*. 1(1): 12-18.
- Nwabueze, A. A. and Garba, A. A. (2015). Growth pattern and condition factor of *Bagrus bayad* from two rivers in southern Nigeria. *G.J.B.B.*, 4 (4): 330-334.
- Nyaku, R.E., Dkeyi, R.G., Yemi, I.Y. and Abdurrahman, M. (2008): Length-Weight Relationship and Condition Factors of Hanees Fish Species in Benue River, Nigeria. *Best Journal*, 5 (3): 204 – 206.
- Perry, R.I., Hargreaves N.B., Waddell B.J. and Mackas L. (1996). Spatial variations in feeding and condition of juvenile pink and chum salmon off Vancouver Island, British Columbia. *Fish Oceanogr.*, 5 (2), 73-88
- Olaosebikan, B.D., Raji, A. (1998) *Field guide to Nigeria freshwater fishes*. Decency Printers and StationaryLtd., Ilorin, Nigeria, pp: 105.
- Oluwusi-Peters ,O.O., Ajibare A.O., Bello –Olusoji O.A. and Oyelade, K.A. (2015). Morpho-Ecological Studies of Some Fish Species in Owena Reservoir Ondo State, Nigeria. *Proceedings of the 30th Annual Conference of the Fisheries Society of Nigeria (FISON)* Delta 381-387
- Seher D. and Suleyman, C.I. (2012). Condition factors of seven cyprinid fish species from Çamlığöze Dam Lake on central Anatolia, Turkey. *African Journal of Agricultural Research*, 7 (31), 4460-4464
- Sikoki , F.D., Hart, A.I. and Abowei F.F.N. (1998). Gill net selectivity and fish abundance in the lower Nun river. Bayelsa. *Journal of Applied Sciences and Environmental Management*. 1:13-19
- Turan, C. (2004) Stock identification of Mediterranean horse mackerel (*Trachurus mediterraneus*) using morphometric and meristic characters. *ICES Journal of Marine Science*; 61:774- 781
- Yadau, B.N. (2002) *Fish and Fisheries*, 2nd edition Chalwa Offset Printers, New Delhi p. 241 – 244.
- Yakubu, A. and Okunsebor, S.A. (2011) Morphometric differentiation of two species (*Oreochromis niloticus* and *Lates niloticus*) using principal components and discriminant Analysis. *International Journal of Morphology* 29: 429-434.

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Comparative Study of Some Physicochemical Parameters of Kitoro Reservoir Across the Wet and Dry Season

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Abstract

The success of a commercial aquaculture enterprise depends on providing the optimum environment for rapid growth at the minimum cost of resources. Water quality plays an important role in achieving success in any fish culturing system. Water samples were collected at kitoro reservoir across the two seasons (wet and dry season) once in a month from June 2020-February 2021 and were examined for Dissolved Oxygen (DO), Biological Dissolved Oxygen (BOD), depth, colour, pH, turbidity, conductivity, alkalinity and temperature using standard methods. Most of the parameters for both wet and dry season fall within the recommended range value except for alkalinity and conductivity which fall below the recommended range value. It was also found out that pH, alkalinity, conductivity and temperature were higher in dry season than in wet season. DO, depth, BOD, turbidity were higher in wet season than in dry season. The reason for this variation in wet and dry season was as a result of human and animal activities, low temperature, settling effect, rain water effect etc. The water was found to be of good quality and suitable for fish culture.

Keywords: physico-chemical parameters, reservoir, wet season, dry season, kitoro

Introduction

Water quality management is a key ingredient in a successful fish culture practice Joseph, (2009). Thus, water quality is one of the determining factor on the success or failure of an aquaculture operation. The quality of water in any ecosystem provides significant information about the available resources for supporting life in that ecosystem. Good quality of water resources depends on a large number of physico-chemical parameters. Assessing and monitoring these parameters essential to identify the magnitude and source of any pollution load Thirupathiahahet *al.* (2012). In the seasonal cyclic phenomenon of the tropical climate, rainfall plays an important role and induces major shifts in water quality changes in the environment. River water quality has been studied to vary with seasons particularly with changes in temperature and rainfall Wahabet *al.* (2019); Suratmanet *al.* (2016). This study aimed to analyze the water quality during the dry and wet seasons.

Materials and Method

Study Area

The study area was kitoro reservoir located at Niffr estate, New Bussa, Niger State. The reservoir was constructed in 2008. It is located at latitude of N9°52'44" and a longitude of E4°32'20". It has a rainy season starting from April\May to October and a dry season starting from November to March.

Sample Collection

The samples were collected in the morning using water sampling bottle between 08:00am to 09:30am and the samples were all analyzed within 24hrs after collection. The water sample was collected once month from June 2020 to February 2021.

Methodology

After the samples were collected, they were analyzed using different laboratory technique as follows; pH was determined by using pH Meter, Depth, Colour and Turbidity was determined using Secchi Disk, Conductivity using Conductivity Meter, Temperature was collected *in-situ* using mercury in glass thermometer, Alkalinity was determined using Titration Method, Dissolved Oxygen was determined using Azide Modification Method and Biological Oxygen Demand through 5days Test.

Results and Discussion

The pH value of dry season which was 7.11 was a little higher than that of wet season which was 7.0. All these values fall within the recommended range values of 6.0-9.0 as recommended by Davies (1993). The pH of wet season which was found to be neutral could be as a result of accumulation of rain water in the wet season.

The colour was yellow-green in wet season while it was Brownish in dry season. The reason for difference in wet and dry season was due to gradual mineralization of nutrient in wet season than in dry season as a result of more water that came into the water body and less human and animal activities around the reservoir in wet season.

Dissolved Oxygen in wet season was 12mg/l and dry season was 5.67mg/l. Dissolved oxygen was higher in wet season than in dry season and this can be attributed to temperature which was lower in wet season, this is because solubility of oxygen is higher in low temperature than in higher temperature and vice versa. The higher dissolved oxygen in wet season simply implies that the reservoir should be stocked with more fish in the wet season and less stocking during the dry season. A Total Alkalinity of 20mg/l or more is necessary for good pond productivity. A desirable range for most aquaculture species lies between 50-150mg/l Wurtsell *et al.* (1992). The total alkalinity obtained in this study shows that the values for both wet and dry season fell below the desired range value (10mg/l and 19.67mg/l respectively). Although the alkalinity in dry season was higher than that of wet season, which could be as a result of more dilution in wet than in dry season.

Conductivity in wet season was 65.60µs/cm and dry season was 71.08µs/cm. This values fall below the recommended range value of 150-500µs/cm for ideal fish culture as recommended by Russell *et al.* (2011). The conductivity was lower in wet season than dry season; this is because of more dilution of salts taking place in wet season than in dry season and there was increased in the volume of water during the wet season. The Depth for wet season was found to be 0.80m and dry season was 0.32m. This shows that the depth of kitoro reservoir was deeper in wet season than in dry season, this is due to high temperature in dry season that result to more evaporation and less evaporation in wet season also more water flows into the reservoir in wet season than in dry season due to the rain water available. Temperature values recorded for the present investigation shows that the temperature was higher in dry season (29.37°C) than wet season (27°C); this could be as a result of the cooling effect during the wet season which makes the temperature in the wet season to be cooler. The found values from both seasons were in accordance with the standards values of 25°C to 30°C suitable for optimum productivity recommended in fish culture by FAO (2006).

Biological Oxygen Demand (BOD) for this study was found to be 4.10mg/l and 3.77mg/l for wet season and dry season respectively. The Biological Oxygen Demand for wet season was higher than Dry season. The reason could be as a result of more floods coming into the reservoir in wet season which in turns brought in more dead materials and decompose to develop more biological organisms and that makes the demand for oxygen higher. The BOD of unpolluted water is less than 1mg/l, moderately polluted water has the BOD range of 2-9 mg/l while heavily polluted water have BOD value more than 10 mg/l (Adakole, 2000). This shows that the reservoir has the potential to develop biological organisms which makes it good for fish culture. Turbidity of the reservoir in wet season (0.25m) was higher than dry season (0.14m). This means that the reservoir was more transparent in wet season and this facilitates photosynthesis which results to increased in DO and thus support plankton growth. The reason for higher turbidity in wet season could be as a result of settling effect of materials and little or no human and animal activities around the reservoir.

Table 1: Table showing the mean value of parameters in wet and dry season

PARAMETERS	WET SEASON	DRY SEASON
pH	7.0±0.06	7.11± 0.12
Colour	YG	B
D.O (mg/l)	12±0.58	5.67±1.37
Alkalinity (mg/l)	10±5.00	19.67±8.98
Conductivity (µs/cm)	65.60±7.37	71.08±29.61
Depth (m)	0.80±0.17	0.32±0.14
Temperature (°C)	27±0.55	29.37±0.58
B.O.D (mg/l)	4.10±0.10	3.77±2.44
Turbidity (m)	0.25±0.02	0.14± 0.10

D.O- DissolvedOxygen, B.O.D- Biological Oxygen Demand, YG- Yellow green, B- Brown

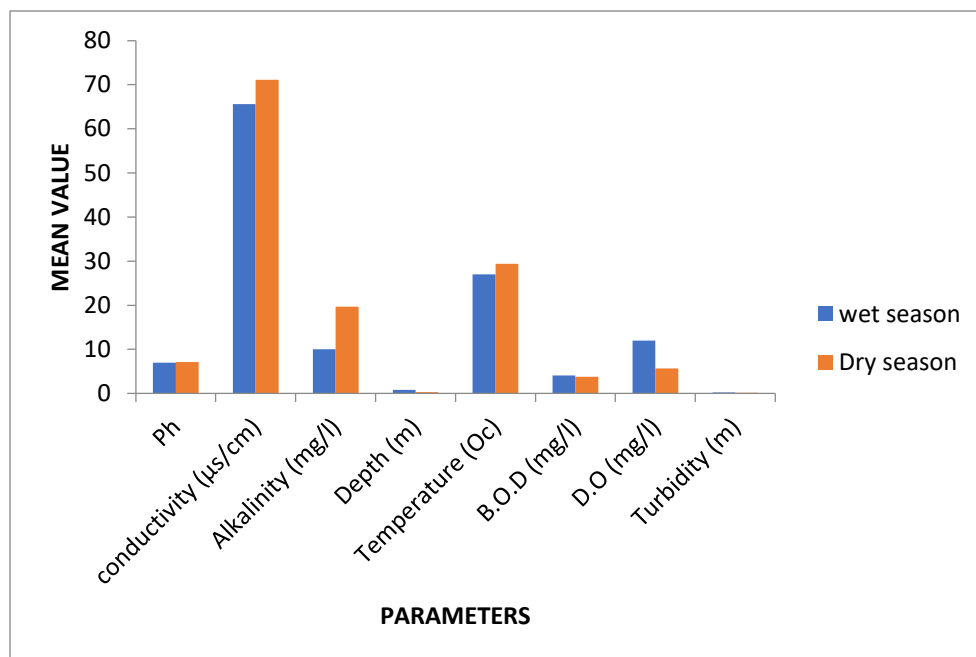


Fig 1: Graph showing physico-chemical parameters in wet and dry season.

Conclusion

Water quality analysis from this research work showed that pH, alkalinity, conductivity and temperature were higher in dry season than in wet season and DO, depth, BOD and turbidity were higher in wet season than in dry season. Most of the parameters for both wet and dry season were found to be good for fish culture except for conductivity and alkalinity which fall below the recommended range value.

References

- Adakole, J.A. (2000). "The effects of domestic, agriculture and industrial effluents on the water quality and biota of Bindare stream", Department of Biological Sciences, Ahmadu Bello University, Zaria, Nigeria, PhD Thesis, 256p.
- Davis, J. (1993). "Survey of Aquaculture effluents permitting and standards in the South". Southern Regional Aquaculture Centre, SRAC. Publication no 465 USA, 4pp.
- Joseph I. (2009). Important management measures in cage culture. In: National training on 'cage culture of Seabass' held at CMFRI, Kochi. 50-56.
- Russell M., Shuke R. and Samantha S. (2011). Effects of conductivity on survivorship and weight of Goldfish (*Carassius auratus*). Available at [http://departments.juniata.edu/biology/eco/documents/Russell et al.pdf](http://departments.juniata.edu/biology/eco/documents/Russell%20et%20al.pdf).23 Apr (2017).
- Suratman, S., Hussein, A.N.A.R., Mohd, Tahir, N., Latif, M. T., Mostapa, R. and Weston, K. (2016). "Seasonal and Spatial Variability of Selected Surface Water Quality Parameters in Setiu Wetland, Terengganu, Malaysia". *Sains Malaysiana*. 45: 551-558.
- Thirupathaiah, M., Samatha, C.H. and Sammaiah, C. (2012). Analysis of water quality using physico-chemical parameters in lower manair reservoir of Karimnagar district, Andhra Pradesh. *International Journal of Environmental Sciences*:3(1):172-180.
- Wahab, N. A., Kamarudin, M. K. A., Toriman, M. E., Juahir, H., Saad, M. H. M., Ata, F.M., Ghazali, A., Hassan, A. R., Abdullah, H., Maulud, K. N., Hanafiah, M. M. and Harith, H. (2019). "Sedimentation and water quality deterioration problems at Terengganu River basin, Terengganu, Malaysia". *Desalination and water Treatment* (149): 228-241.
- Wurts, W. A. and R. M. Durbinow. (1992). Interactions of pH, carbon dioxide, alkalinity and hardness in fish ponds. Southern Regional Aquaculture Center Publication No. 464.

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Determination of Length-Weight Relationship and Condition Factor of African Snakehead, *Parachanna obscura* (Gunthers, 1861) In River Rima, Sokoto, Nigeria

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Abstract

This study was carried out in Usmanu Danfodiyo University, Sokoto to determine the length-weight Relationships and condition factor of *Parachanna obscura* from River Rima, Sokoto, Northwest, Nigeria. A total of 50 fish samples were collected from artisanal fishermen at their landing site biweekly for 3 months. The standard length (cm) and body weight (g) were measured. The length-weight relationship and condition factors were determined from the data collected. The statistical tools used in the analyses include; descriptive statistics, Regression and correlation. The LWR revealed negative allometric growth patterns. This was attributed to the body form of the fish (fussiform). Further researches were therefore recommended on the biology of this species.

Key words: Length-weight relationship, condition factor, African Snake head, River Rima

Introduction

There is an increasing demand for fish production through aquaculture in Nigeria. One of the species being screened for aquaculture is African snakehead, *Parachanna obscura*. Snakeheads are of high commercial value because of the good taste and high quality flesh (Mat Jais *et al.* 1998). It could be recommended for post-operation patients. Snakeheads are considered to be more nutritive than Carp or Tilapias, in terms of a higher protein-to-fat ratio (Sharma and Simlot, 1971). The name "snakehead fish" can anticipate feelings of snake than of a delicious fleshy fish dish common in some African countries. The Obscure Snakehead Fish, *Parachanna obscura* is a widely distributed freshwater fish endemic to Africa. It is a hardy species that can survive stressful conditions with rapid growth performance and upcoming aquaculture potential (Olaosebikan *et al.*, 1998). It is a fish highly appreciated by the people of Africa where it is found because of its high nutritional value and economic potential. Its production in wild natural continental waters cannot meet local demands because of over harvesting (Kpogue *et al.*, 2013). Poor harvesting methods using poisonous chemicals, fire and dynamite along with the improper netting of fish has affected the fish species and the human consumers. Proper extension services back up by research and engagement of fish breeders can enhance the farming of this fish species and provide good source of protein; therefore contributing to food and nutrition security and improved livelihood of the growing Africa's population, in order to ensure conservation of Africa's aquatic biodiversity.

Parachanna obscura, commonly known as African snakehead is a freshwater species that belongs to the family *Channidae* and order *Perciformes*. African snakehead like other snakehead fishes is characterized by an elongated body, fussiform, sub cylindrical covered with cycloid scales of medium size. It also has a flattened head with large and protractile mouth. This fish is a natural inhabitant of ponds, streams, rivers, lakes, lagoons, marshes, floodplains and creeks of swamps (Adeosun *et al.*, 2011; Agbugui 2013). It is a voracious pelagic carnivore, a formidable predator, a typical piscivorous, an insectivore and a consumer of crustaceans (Ahmad *et al.*, 2012). *Parachanna obscura* is an economically important fisheries resource in Africa. Also in recent times, it has got its entry into aquaculture and has been reported to be cultured in extensive farming in Nigeria, Cameroon, Gabon and Democratic Republic of Congo and Ivory Coast (Anderson *et al.*, 1996; Ayoade 2011). However, wild populations of this species has reportedly undergone decline in range and abundance due to over-exploitation and degradation of their habitat (Babatunde *et al.*, 2010; Bassey *et al.*, 2010). Hence, due to economic importance and concerns about their conservation.

A better understanding of the life and growth parameters of the individual species is crucial for management of this freshwater fish. The length-weight relationship and condition factor of fish has got significant role in fisheries management. This relationships can be used in estimating the average weight at a given length group (Beyer, 1987) and in estimating the health status of the fish population (Bhatta *et al.*, 2014; Musikasinthorn, 2000). Length and

weight data provide statistics that are cornerstones in the foundation of fisheries research and management. (Anderson and Neumann, 1996) refer to length-weight data as basic parameters for any monitoring study of fishes since it provides important information concerning the structures and function of population. In fishes, condition factor reflects through its variations and provides information on the physiological state of the fish in relation to its welfare. However, scientific concerns about the sustainability of the African snakehead populations have led to several studies of the population biology and distribution of *P. obscura* in inland water bodies of Nigeria. Notable among these is the report of (Bolaji *et al.*, 2011) on the Preliminary study on the aspects of the biology of snakehead fish *P. obscura* in a Nigerian wetland.

However, there is dearth of such data on the fish species population of *P. obscura* from river Rima, Sokoto. This needs a quick response as a contribution to the candidacy of this species for aquaculture in Nigeria. Therefore the result of this research provides baseline information on the length-weight relationship and condition factor of *P. obscura* and also for future research or researcher that wishes to work on the biology of *P. obscura*.

Materials and Methods

Study Area

This research was conducted in Usmanu Danfodiyo University Sokoto, located in the Savannah agro-ecological zone (Latitude 13 00' 27.0"N and Longitude 5 15'05.6"E), about 350m above the sea level. (Google map, 2011). The rainfall establishes between mid-May to early June and reaches the peak in August. The climate is semi-arid and dry season starts in mid-October and ends in late April. The coolest months are November to January which is characterized by dry Harmattan wind (SERC 2012). The area received an average annual temperature of 30.26 °C with average rainfall of 26.55 mm², with average annual relative humidity of 48.54% (SERC 2012).

Materials Used

The materials used include; Measuring board and a sensitive weighing scale (2Kg capacity).

Sample Collection

A total of 50 samples of *Parachanna obscura* were collected from River Rima, Sokoto. The samples were collected between August and September, samples collected were taken to the research laboratory of fisheries Department in Usmanu Danfodiyo University Sokoto, and the fish samples were weighed using sensitive weighing scale with the carrying capacity of 2kg.

Data collection

Data collected include; Body weight (BW), Total length (TL) and Standard length (SL) which were used in the determination of the Length-weight relationship and condition factors of the fish samples collected across the sampling period.

Data Analyses

Length-weight relationship was estimated using the equation: $TW = aL^b$ (Ricker, 1971).

The condition factor was determined by the formula: $K = 100TW/L^b$

Where; a= intercept on y-axis; b= an exponent between 2 and 4; K= condition factor; L= length (cm); TW= total weight (g) (Bagenal and Tesch, 1978).

Data collected were analyzed using one-way analysis of variance (ANOVA). The results were expressed as Means ± SE. significant differences among means were determined using Duncan Multiple Range Test (DMRT) at p= 0.05 significant level. Relationship between length and weight were carried out using correlation and regression analysis.

Results

Table 1: Mean $\pm$ SE (standard Error); Size Distribution of *P. obscura* from river Rima between August and October, 2019

S/ N	Morphometric	Late August	Mid- September	Late-September	Mid-October	Mean $\pm$ SE (standard Error)
1	BW	51.90 $\pm$ 7.10	182.40 $\pm$ 44.93	171.10 $\pm$ 45.24	146.90 $\pm$ 16.38	146.06 $\pm$ 16.56
2	TL	25.90 $\pm$ 1.41	27.20 $\pm$ 2.02	22.90 $\pm$ 2.24	26.40 $\pm$ 1.03	26.84 $\pm$ 0.77
3	SL	21.20 $\pm$ 1.12	21.90 $\pm$ 1.90	22.50 $\pm$ 2.09	21.70 $\pm$ 0.96	21.80 $\pm$ 0.70

Table 2: Length-Weight Relationship and Condition Factor of *P. obscura* from River Rima between August and October, 2019

	A	BW	B	SE of A	SE of B	K Factor	SE of BW
Late August	0.26	51.90	1.80	0.44	0.33	0.67	7.10
Mid-September	0.52	182.40	2.02	0.54	0.41	0.77	44.93
Late September	0.52	171.10	2.02	0.54	0.41	0.77	45.24
Mid October	0.26	149.90	1.80	0.44	0.33	0.67	16.38
Late October	0.26	175.09	1.80	0.45	0.33	0.67	41.29

Discussion

Size Distribution of *P. obscura* from River Rima between August and October 2019 Size distribution of the fish samples measured revealed that the highest body weight was recorded at the early September; this is the period of bounties of food availability for such an insatiable carnivore like *P. obscura*. As reported by Diana *et al.* (1985), Snakehead can easily consume a smaller fish of more than half its length. *P. obscura* is a voracious pelagic carnivore, a formidable predator, a typical piscivore, an insectivore and a consumer of crustaceans (Reed *et al.*, 1967; Bonou and Teugels 1985; Bailey 1994; Paugy and Leveque 2006). This research inserted that since the research area has the rainfall establishing between mid-May to early June and reaches the peak in August. The climate is semi-arid and dry season starts in mid-October and ends in late April. The coolest months are November to January which is characterized by dry Harmattan wind (SERC 2012). Looking at the report by SERC (2012), stated above, the research was carried out during the raining season when all factors, such as, temperature, humidity, food availability and water level of the River Rima itself is high enough to support aquatic productivity.

Length-Weight Relationship and Condition Factor

Length-weight relationship (LWR) provides information on growth patterns and growth rate of animals. Ayoade (2011), asserted that during fish developmental stages, fish are known to pass through stages in their life history which are defined by different length-weight relationships. The diets depend on the developmental stages of *P. obscura*. Larvae feed on algae and protozoa (Blache *et al.*, 1964). An analysis of stomach contents of juveniles and adults of *P. obscura* showed not only the presence of fry different fish species but also insects, tadpoles, copepods and shrimps (Imevbore and Bakare 1970) they are insectivore-piscivores-invertivores. Also, *P. obscura* has background enzyme allowing it to digest proteins, fats and carbohydrates contained in food (Fagbenro *et al.* 2005; Odedeyi 2007). However, the results of this research depict negative allometric growth pattern for virtually all the measured sample groups, with the highest “b” values of 2.02 and b values of as low as 1.80. Also, variations occurred in the growth pattern and condition factor of this species with season and sizes. The condition factor (K) of this species maybe low but that does not mean they are not in good condition of health, of course they are, it only depict the type of body form of the fish which is fusiformic and sub-cylindrical in nature i.e the snakelike body shape.

Conclusion

In conclusion, the Morphometric characters of *P. obscura* measured exhibited morphological variations in head Morphometric parameters, general body Morphometrics and the meristic characters. Among the sample groups, the Morphometric characters measured shows diversified phenotypes. *P. obscura* has been a potential aquaculture candidate in Nigeria, it has been revealed in recent researches on the investigation of additional freshwater fish species for the improvement of aquaculture in the country. The baseline knowledge of Morphometric characters,

length-weight relationship and condition factor will serve huge advancement in contributing to the understanding of the genetics and biology of *P. obscura* from River Rima. It is therefore recommended that more researches should be carried out in the area of other biological aspects of this fish species from this research area and this should be extended to other part of the country (Nigeria).

References

- Adeosun F.I, Omoniyi I.T, Akegbejo-Samsons Y, Olujimi O.O (2011) the fishes of the Ikere Gorge drainage system in Ikere, Oyo State, Nigeria: taxonomy and distribution. *Asiatic Journal of Biotechnology Resources* 2:374-383.
- Agbugui MO (2013) Length-Weight Relationship and Condition Factor of *Pomadasys Jubelini* in the New Calabar-Bonny River, Nigeria. *World Rural Observations* 5: 50-53.
- Ahmad DS, Najar AM, Balkhi MH, Rather MA, Sharma R (2012) Length-weight relationship and relative condition factor of *Schizopyge esocinus* (Heckel, 1838) from Jhelum River, Kashmir. *International Journal of Aquatic Science* 3: 29-36.
- Anderson OR, Neumann RM (1996) Length-Weight and Associated Structural Indices In: Nielsen LA, Johnson D (Editors), Bethesda. Fisheries Techniques, American Fisheries Society, Bethesda, MD pp: 732.
- Ayoade AA (2011) Length-weight relationship and Diet of African Carp *Labeo ogunensis* (Boulenger, 1910) in Asejire Lake Southwestern Nigeria *Journal of Fisheries and Aquatic Science* 6: 472-478.
- Babatunde EE, Olojede ET (2010) Comparative studies on the catch selectivity of galvanized wire gauze trap from fresh and brackish water tropical creeks in south-western Nigeria. *Journal of Life and Physical Science* 3: 91-101.
- Bailey RG (1994) Guide to the fishes of the River Nile in the Republic of the Sudan. *J Natu Hist* 28:937
- Bassey AU, Ajah PO (2010) Effect of three feeding regimes on growth, condition factor and food conversion rate of pond cultured *Parachanna obscura* (Gunther, 1861)(Channidae) in Calabar, Nigeria *Turkish Journal of Fisheries and Aquatic Sciences* 10: 195-202.
- Beyer JE (1987) on length-weight relationships: Part I: Computing the mean weight of the fish in a given length class. *ICLARM Fishbyte* 5:11-13.
- Blache J, Miton F, Stauch A, Iltis A, Loubens G (1964) Lespoissons du bassin du Tchad et du bassin adjacent du Mayo-Kebbi: etude syste'matique et biologique. Publ. ORSTOM, Paris, 483 p, multigr
- Bolaji BB, Mfon TU, Utibe DI (2011) Preliminary study on the aspects of the biology of snakehead fish *Parachanna obscura* (Gunther) in a Nigerian wetland. *Afri J Food Agricultural Nutr Dev* 11(2):4708–4717
- Bonou CA, Teugels GG (1985) Re'vision syste'matique du genre *Parachanna* (Teugels and Daget 1984) (Pisces: channidae). *Rev Hydrobiol Tropi* 18(4):267–280
- Diana JS, Chang WYB, Ottey DR, Chuapoehek W (1985) Production systems for commonly cultured freshwater fishes of Southeast Asia. International program report Great Lake and Marine Water Center, University of Michigan. *Ann Arbor* 7:75–79
- Fagbenro O, Adedire O, Fateru O, ± Owolabi I, Ogunlana O, Akanbi B, Fasanmi T, Ayo-Amu P (2005) Digestive enzyme assays in the gut of *Oreochromis niloticus* (Linnaeus, 1757), *Parachanna* (*Channa*) *obscura* (Gunther, 1861) and *Gymnarchus niloticus* (Cuvier, 1829). *Ani Red Int* 2(2):292–296
- Gunther A. (1861) Catalogue of the Acanthopterygian fishes. The Trustees, London, vol. III, 586 p
- Imevbore AMA, Bakare O (1970) The food and feeding habits of non-cichlid fishes of the river Niger in the Kainji reservoir area. In: Viser SA (ed) *Kainji Lake Studies*, vol. 1. Ecology NISER/Ibadan University Press, pp 49–61
- Ita EO (1984) *Kainji* (Nigeria). In: Kapetsky J.M, Petr T. (eds) *Status of African reservoir fisheries*. CIFA tech paper, volunteer 10, pp 43–103
- Kpogwe, D.N.S., Mensah, G.A., Fiogbe, E.D. (2013) . A review of biology, ecology and prospect for aquaculture of *Parachanna obscura*. *Reviews in Fish Biology and Fisheries*. Vol.23, Issue 1, pp 41 - 50.
- Mat Jais, A.M., M.F. Matori, P. Kittakoo and K. Suwanborirux, 1998. Fatty acid compositions in mucus and roe of Haruan, *Channa striatus*, for wound healing. *Genet. Pharmacol.*, 30: 561-563.
- Olaosebikan, B.D. and Raji, A. (1998) . A field guide to Nigerian freshwater fishes. FCFPT, New Bussa. Nigeria.
- Reed WJ, Burchard AT, Hopson J, Yaro Y (1967) Fish and fisheries of Northern Nigeria. Ministry of Agriculture, Northern Nigeria 226 p
- Ricker WE. 1971. Linear regressions in fisheries research. *J. Fish. Res. Board. Canc.*, 30: 409 - 434.
- Sharma, K.P. and M.M. Simlot, 1971. Chemical composition of some commercially important fishes of Jaisamand Lake, Udaipur. *J. Inland Fish. Soc. India*, 3:121-122.

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Freshwater Pollution And Fish Health: Impact Of Heavy Metals**Mu'azu, M.M, Magaji, I. and Moses, Y.**

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Abstract

Heavy metals pollution of freshwater bodies is a growing global problem because heavy metals can be present as mineral deposits in soils and rocks which can be deposited in aquatic systems via erosion and leaching. They are also present in untreated industrial effluent from manufacturing firms which is often discharged indiscriminately into receiving aquatic environments without prior treatment. This problem is more serious in developing countries where there is no adequate measures in place to enforce laws that protect water bodies from point and non-point source industrial effluent discharges. To further compound this problem, even the culprits of this issue are not aware of the implications of their actions on the health status of receiving aquatic ecological systems. Heavy metals are extremely toxic to fish due to the fact that most of them bioaccumulate and magnify in the tissues of fish. They bioaccumulate in fish tissues such as gills, liver and kidney because they cannot be metabolized in the body of the fish. Therefore, they persist and increase in concentration in the tissues of aquatic organisms where they cause several health issues which eventually lead to mortality. Amidst these issues, it is worrisome to know that heavy metals can be transferred from fish to humans when contaminated fish is consumed. The aim of this review is to generally assess the impact of heavy metals pollution on fish health and proffer possible remedies to tackle this menace so as to ensure sustainability of the environment, fisheries and public health in general.

Key words: Pollution, Metals, Fish, Environment, Health, Impact

Introduction

Heavy metals are metallic elements that have relatively high densities, atomic weights and atomic numbers that can either be harmless or toxic when they accumulate in tissues of the human body as well as that of other animals. This is because some heavy metals such as iron (Fe) and zinc (Zn) are actually essential nutrients required for body metabolism while others such as Cadmium (Cd), lead (Pb) and Mercury (Hg) are extremely poisonous particularly when they accumulate to toxic concentrations in the tissues of animals (Shafaqat *et al.*, 2014). Sources of heavy metals pollution in receiving freshwater environments are agricultural run-off, industrial effluents, domestic effluents and mining activities. When these pollutants find their way into aquatic ecosystems, they pose a risk to both human health and the environment. According to (Saniet *et al.*, 2019), the major sources of heavy metals pollution in Nigeria are industrial effluents discharged from various manufacturing industries. The practice of indiscriminate effluent discharge into aquatic systems in Nigeria by industries is a major problem because the Federal Environmental Protection Agency (FEPA) established to curb these environmental menaces has had little or no impact on pollution control in Nigeria (Ezeronye and Amogu, 1998). Oluseun (2013) lamented that effluent discharge practices in Nigeria are done indiscriminately without regards to environmental health and sustainability, especially in the industrialized parts of the country such as Lagos, Kano, Anambra and Abia States. The aim of this review is to generally assess the impact of heavy metals pollution on fish health as it relates to the survival and general well-being of fish and proffer possible solutions or remedies to abate this menace so as to ensure sustainability of the environment and fisheries in general.

Sources and Causes of Heavy Metals Pollution in Freshwater Bodies

Freshwater pollution is a growing problem in developing and underdeveloped countries due to lack of enforcement of laws on effluent discharge from manufacturing industries. However, presence of heavy metals in freshwater bodies have been reported to be caused not only by discharge of industrial wastewater, but also by natural processes such as leaching and erosion (Mahboob *et al.*, 2020). According to Ubani-Rex *et al.* (2017), toxic heavy metals in the aquatic environment can be traced to both natural and anthropogenic sources. Similarly, some very toxic heavy metals such as Lead (Pb) are naturally present in the environment (air, water, soil and food) while others such as Nickel (Ni) is a common byproduct of electroplating industries, steel production, metal mining, smelting, refining, ceramic and processing along with fuel combustion, and waste ignition activities. Meanwhile, some causes of heavy metals pollution in freshwater bodies in Nigeria are highlighted in Table 1.

Table 1: Causes and Sources of Heavy Metal Pollutants			
Heavy Metal	Source	Cause of pollution in freshwater bodies	Reference
Aluminum (Al)	Mining activities, industrial effluents.	Erosion and Leaching	Shahbaaet <i>al.</i> , 2020
Lead (Pb)	Natural source: Rocks, Air and soil sources. Anthropogenic source: Tannery wastewater, Mining activities, recycled lead batteries and wastewater from industries.	Point and non-point discharges, erosion and leaching	Mitchel, 1964 Bernard and Ogunleye, 2015; Saniet <i>al.</i> , 2019
Cadmium (Cd)	Effluent from Textile industries, effluent from Tannery industries	Point and non-point discharges, erosion and leaching	Bernard and Ogunleye, 2015; Odipeet <i>al.</i> , 2018; Saniet <i>al.</i> , 2019.
Mercury (Hg)	Run-off from crop farms, pesticides and herbicides.	Leaching of Fungicide residues from crop farms	Selvanathanet <i>al.</i> , 2013
Arsenic (As)	Natural source: mineral deposit in soil and rocks. Anthropogenic source: Tannery effluent, Pharmaceutical industrial effluent, pesticides	Leaching and erosion. Point and non-point discharges.	Garbaet <i>al.</i> , 2008; Sylvester and Srivastav, 2015
Chromium (Cr)	Natural source: Deposits in soil and rocks. Wastewater from residential buildings, municipal and industrial wastewater.	Leaching and erosion. Point and non-point discharges.	Oguzie and Okhagbuzo, 2010 Odipeet <i>al.</i> , 2018; Saniet <i>al.</i> , 2019.
Nickel (Ni)	Natural source: mineral deposit in soil and rocks. Anthropogenic source: Recycling of Ni-Cd battery cells, catalysts for petroleum refining, alloy production, Nickel plate items and burning of fossil fuels.	Weathering of mineral rocks and atmospheric deposition, point and non-point discharges.	Merian, 1991; Robinson, 1996; Emoyanet <i>al.</i> , 2006.

Impact of Heavy Metals on Fish Health

Numerous studies have reported several abnormalities in the internal organs of fish exposed to various concentrations of heavy metals in the aquatic system. These abnormalities are revealed when histopathological investigations of internal organs of fish such as gills, muscles (flesh), kidney and liver are conducted. Other studies also reported changes in hematological indices of fish exposed to heavy metals (Oshodeet *al.*, 2008; Ololade and Oginni, 2010). The degree or extent of these abnormalities depend on predisposing factors such as nature of heavy metal or metals, duration of exposure, concentration of heavy metal or metals and water chemistry profile of the aquatic environment (Galat,*et al.*, 1985).

Furthermore, health issues on fish health associated with heavy metals toxicity do not stop with fish survival and well-being, it extends to the higher trophic level where the health of potential consumers of such fish is at a great risk. This is because fish normally bioaccumulates heavy metals from food, water and sediments in its tissues

(Yilmazet *al.*, 2007; Zhao *et al.*, 2012). The presence of toxic heavy metals in fish tissues can lead to severe health issues in human consumers. Kidney/renal failure, liver damage, cardiovascular diseases and death have all been reported as consequences of heavy metals toxicity in humans (Bawuroet *al.*, 2018).

Table 2: Impact of heavy metals on fish health

Heavy Metal	Effect on Fish Health	Fish Species	References
Aluminum (Al)	Interference with physical and chemical cellular processes in fish, respiratory stress and coagulation of mucous on gills.	<i>Oreochromis niloticus</i> , Rainbow trout (<i>Oncorhynchus mykiss</i>)	Shahbaaet <i>al.</i> , 2020
Arsenic (AS)	Histopathological changes such as degeneration liver and kidney cells as well as necrosis. Enlargement of intestinal mucosa and sub-mucosa.	Catla (<i>Catla catla</i>) <i>Clarias gariepinus</i> <i>Cyprinus carpio</i>	Ahmed <i>et al.</i> , 2008 Lavanya <i>et al.</i> (2011) Hamdi <i>et al.</i> (2009) Kovendan <i>et al.</i> (2013) Hossain, 2012
Mercury (Hg)	Affects the nervous system, convulsions and ataxia. Others are inflammation of the liver and degeneration of blood vessels. Degeneration of renal tubules. Low survival rate of eggs and fries even at low concentration. Low sperm count due to alteration of the structure of testes.	<i>Clariasbatarachus</i> , <i>niloticus</i>	<i>Oreochromis</i> Selvanathanet <i>al.</i> , 2013 Western and Canton, 1992 Ralduaet <i>al.</i> , 2007 Zhenget <i>al.</i> , 2013
Lead (Pb)	Shrinkage of gill lamella. Hepatic cells vacuolation, nuclear pyknosis, Liver cirrhosis and nervous system disorder.	Grass carp (<i>Ctenopharyngodonidella</i>). <i>Clariasbatarachus</i>	Olojoet <i>al.</i> , 2005 Ghosh <i>et al.</i> , 2006
Lead (Pb) and Cadmium (Cd)	Liver edema and cloudy appearance	Tilapia (<i>Oreochromis niloticus</i>).	Hamouda, 1993; Hamouda, 1996

Chromium (Cr)	Necrosis of epithelial cells and thickening of the blood cell. Increased mucous secretion, suffocation and death.	<i>Oreochromis niloticus</i> , <i>Labeorohita</i>	Roberts and Oris, 2004 Muthuku and Raja, 2013
Chromium (Cr)	Liver: Vascular and hydropic changes of the hepatocytes, prominent coagulative necrosis.	Tilapia (<i>Oreochromis niloticus</i>)	Hamouda, 1993
Mercury (Hg)	Liver congestion and Hemorrhage.	Tilapia (<i>Oreochromis niloticus</i>)	Hamouda, 1993; Hamouda, 1996; Abdullah <i>et al.</i> , 2008
Mercury (Hg) and Lead (Pb)	Liver: Degeneration of cytoplasm in hepatocytes	Tilapia (<i>Oreochromis niloticus</i>)	Velchevaet <i>al.</i> , 2010
Mercury (Hg), Lead (Pb), Cadmium (Cd) and Chromium (Cr)	Kidney: Renal necrosis, interstitial nephritis.	Grass carp (<i>Ctenopharyngodonidella</i>), Common carp (<i>Cyprinus carpio</i>), Bata, (<i>Labeobata</i>), Tilapia (<i>Oreochromis niloticus</i>)	Zeitoun and Mehana, 2014
Mercury (Hg), Lead (Pb), Cadmium (Cd) and Chromium (Cr)	Skin: Hyperactivation of goblet cells and dermal melanosis, dermal granuloma.	Grass carp (<i>Ctenopharyngodonidella</i>), Common carp (<i>Cyprinus carpio</i>), Bata, (<i>Labeobata</i>), Tilapia (<i>Oreochromis niloticus</i>)	Zeitoun and Mehana, 2014
Mercury (Hg), Lead (Pb), Cadmium (Cd) and Chromium (Cr)	Brain: Symptoms of meningitis and gliosis.	Grass carp (<i>Ctenopharyngodonidella</i>), Common carp (<i>Cyprinus carpio</i>), Bata, (<i>Labeobata</i>), Tilapia (<i>Oreochromis niloticus</i>)	Zeitoun and Mehana, 2014
Mercury (Hg), Lead (Pb), Cadmium (Cd) and Chromium (Cr)	Gills: Edema, separation and fusion of gill rakers.	Catla (<i>Catla catla</i>), Rui (<i>Labeo rohita</i>), Tilapia (<i>Oreochromis niloticus</i>)	Velchevaet <i>al.</i> , 2010; Shah, 2017.
Mercury (Hg), Lead (Pb), Cadmium (Cd) and Chromium (Cr)	Expansion of the Cartilaginous base of gill arches.	Catla (<i>Catla catla</i>), Rui (<i>Labeo rohita</i>), Tilapia (<i>Oreochromis niloticus</i>)	Velchevaet <i>al.</i> , 2010; Shah, 2017.

Conclusion

Heavy metals are extremely toxic and harmful environmental pollutants that affect the biochemical, physiological, metabolic and genetic states of aquatic organisms once they are present in the aquatic environment. They interfere with the general physiology and metabolism of fish by inducing histological changes in fish organs, thereby interfering with the normal functions of their organs. Histological changes in such organs can manifest as morphological and functional anomalies such as edema, necrosis, hyperplasia or just degenerative changes in tissues or cells of these organs. Heavy metals can persist in the tissues of both fish and man to extreme concentrations that can cause more serious health problems in fish and even in humans when they consume contaminated fish.

Recommendations

With the lingering apathetic behavior of regulatory and enforcement authorities concerned with protecting water bodies from pollution in Nigeria, the menace of heavy metals pollution in our water bodies will continue to surge. If this continues, undesirable consequences should be expected to happen in the nearest future. It is therefore,

necessary that concerned groups as well as Governments at Federal, State and Local levels adopt needed measures aimed at protecting freshwater bodies from heavy metals pollution through the following measures:

- Strict enforcement of laws that protect our water bodies from pollution caused by discharge of untreated industrial effluent. Manufacturing firms should be made to abide by the effluent discharge limits or be made to face penalty measures such as huge taxes or even prosecution. Wastewaters from factories must be made to meet effluent discharge limit set by National Environmental Standards and Regulatory Enforcement Agency (NESREA) prior to discharge into water bodies
- National awareness through regular campaigns and civil education on the dangers and potential consequences of water pollution in Nigeria.

References

- Atchison, G.J., Mary, G.H. and Mark, S. (1987). Effects of metals on fish behavior. *Environ. Biol. Fishes* Vol.18, no. 1, pp.11–25.
- Bawuro, A.A., Voegborlo, R.B. and Adimado, A.A. (2018). Bioaccumulation of heavy metals in some tissues of fish in Lake Geriyo, Adamawa State, Nigeria. *Journal of Environmental and Public Health*, vol 3, no. 2, pp. 3-7.
- Bernard, E. and Ogunleye, A. (2015). Evaluation of tannery effluent content in Kano metropolis, Kano state, Nigeria. *International Journal of Physical Sciences*, vol. 10, issue 9, pp. 306-310.
- Galat, D.L., Post, G., Kerfe, T.J. and Boucks, G.R. (1985). Histopathological changes in the gills, kidney and liver of Lohonta cut throat trout, *Salmo Clarki* Henshaw, living in Lakes of different salinity and alkalinity. *Journal of Fish Biology*, vol. 27, pp. 533-552.
- Garba, Z.N., Gimba, C.E., Hamza, S.A. and Galadima, A. (2008). Tetrimetric determination of arsenic in well water from Getso and Kutama, Gwarzo Local Government Area, Kano state, Nigeria. *Chem. Class. Journal*, 5, 78-80.
- Hamdi M., Sanchez, M.A., Beene, L.C., Liu, Q., Landfear, S.M., Rosen, B.P. and Liu, Z. (2009). Arsenic transport by zebra fish aqua glyceroporins. *BMC Mol Biol* volume 10, issue 1, pp. 104
- Hamouda, E.E. (1993). Pathological studies on fish of some chemically polluted areas at Alexandria province. MVSC Thesis, Department of pathology and parasitology, faculty of veterinary medicine, Alexander University, Egypt.
- Hamouda, E.E. (1996). Pathological studies on fish experimentally intoxicated by certain heavy metals. Ph.d Thesis, Department of pathology and parasitology, faculty of veterinary medicine, Alexander University, Egypt.
- Kovendan, K., Vincent, S., Janarthanan, S. and Saravanan, M. (2013). Expression of metallothionein in liver and kidney of freshwater fish *Cyprinus carpio* var. communis (Linn) exposed to arsenic trioxide. *American Journal of Sci Ind Res*, volume 4, issue 1, pp.1–10
- Lavanya S, Mathan R, Chokkalingam K, Annamalai M (2011). Hematological, biochemical and ion regulatory responses of Indian major carp *Catla catla* during chronic sub lethal exposure to inorganic arsenic. *Chemosphere*, issue 82, pp.977–985.
- Mahboob, S., Al-Ghanim, K.A., Al-Balawi, H.F., Al-Misned, F. and Ahmed, Z. (2020). Toxicological effects of heavy metals on histological alterations in various organs in Nile Tilapia (*Oreochromis niloticus*) from freshwater reservoir. *Journal of King Saud University*, vol. 32, pp. 970-973.
- Merian E. (1991). Metals and their compounds in the Environment. Occurrence Analysis and Biological Relevance UCH, Weintraen – New York, pp. 216-312.
- Mitchell, R. L. (1964). Chemistry of the soil, in *Trace Elements in Soil*, ed F. E. Bear (New York, NY: Reinhold Publishing Corp.), pp.320–368
- Odipe O.E., Olalekan, R.M. and Suleiman, F. (2018). Assessment of Heavy Metals in Effluent Water Discharges from Textile Industry and River Water at Close Proximity: A Comparison of Two Textile Industries from Funtua and Zaria, North Western Nigeria. *Madridge J Agric Environ Sci*. vol. 1, issue 1, pp. 1-6.
- Olojo, E.A.A., Olurin, K.B., Mbaka, G. and Oluwemimo, A.D. (2005). Histopathology of the gill and liver tissues of the African Catfish, *Clarias gariepinus* exposed to Lead (Pb). *African Journal of Biotechnology*, vol. 4, issue 1, pp. 117-122.
- Ololade, I.A. and Oginni, O. (2010). Toxic stress and hematological effects of nickel on African Catfish, *Clarias gariepinus* fingerlings. *Journal of Environmental Chemistry and Ecotoxicology*. Vol. 2, issue 2, pp. 14-19.
- Oluseun, A.O. (2013). Freshwater Pollution in Some Nigerian Local Communities, Causes, Consequences and Probable Solutions. *Academic Journal of Interdisciplinary Studies*, volume 2, issue 13, pp. 111-118.

- Oguzie, F.A. and Okhagbuzo, G.A. (2010). Concentrations of heavy metals in effluent discharges downstream of Ikpoba River in Benin City, Nigeria. *African Journal of biotechnology*, vol. 9, issue 3, pp. 319-325.
- Oshode OA, Bakare AA, Adeogun AO, Efuntoye MO, Sowunmi AA (2008). Ecotoxicological assessment using *Clariasgariepius* and microbial characterization of leachate from municipal solid waste landfill. *Int. J. Environ. Res.* 2(4): 391-400.
- Roberts, A.P. and Oris, J.T. (2004). Multiple biomarker response in Rainbow trout during exposure to hexavalent Chromium (Cr). *Comp. Biochem. Physiol.* Vol, 138, pp. 221-238.
- Sani, A., Darma, A.I., Rukkaya, A.A. and Namadina, M.M. (2019). A study of physicochemical parameters and heavy metals in Sharada industrial effluents, Kano, Nigeria. *Innovare Journal of Life Sciences*, vol. 7, issue 3, pp. 1-4.
- Shah, A.I. (2017). Heavy metal impact on aquatic life and human health: An overview. IAIA17 Conference Proceedings | IA's Contribution in Addressing Climate Change 37th Annual Conference of the International Association for Impact Assessment, 4 - 7 April 2017 | Le Centre Sheraton | Montréal | Canada
- Selvanathan, J., Vincent, S. and Nirmala, A. (2013). Histopathology changes in freshwater fish *Clariasbatrachus* (Linn.) exposed to Mercury and Cadmium. *International Journal of Pharmacy and Teaching Practice*, vol. 3, no. 4, pp.422-428.
- Shahbaa, K.A., Karam, H. and Ismail, H.K. (2020). Review on Some Heavy Metals Toxicity on Freshwater Fishes. *Journal of Applied Veterinary Sciences*, vol. 5, issue 3, pp. 78-86.
- Shafaqat, A., Mujahid, F., Bharwana, S.A. and Hannan, F. (2014). Effect of different heavy metals pollution on fish. *Research Journal of Chemical and Environmental Sciences*, vol. 2, issue 1. Pp. 74-79.
- Sylvester, C.I. and Srivastav, A.L. (2015). Level of Arsenic in Portable water sources in Nigeria and their potential health impact, a review. *Journal of Environmental Treatment Techniques*, vol. 3, issue 1, pp. 15-24.
- Ubani-Rex, O.A., Saliu, J.K. and Bello, T.H. (2017). Biochemical effects of the toxic interaction of Copper, Lead and Cadmium on *Clariasgariepinus*. *Journal of Health and Pollution*. Vol. 7, no. 16.
- Velcheva, E., Tomova, D., Arnaudova, D. and Arnaudo, A. (2010). Morphological investigation on gills and liver of freshwater from Dam Lake "Student Kladenets" *Bulgarian Journal of Agricultural Sciences*, vol. 16, issue 3, pp. 364-368.
- Yilmaz, F., Ozdemir, N., Demirak, A. and Tuna, A.L. (2007). Heavy metal levels in two fish species; *Leucisuscephalus* and *Lepomisgibbosus*. *Food Chemistry*, vol. 100, no. 2, pp. 830-835.
- Zeitoun, M.M. and Mehana, E. (2014). Impact of water pollution with heavy metals on fish health. Overview and update. *Global Veterinaria*, vol. 12, issue 2, pp. 219-231.
- Zhao, S., Feng, C., Quan, W., Chen, X., Niu, J. and Shen, Z. (2012). Role of living environments in the accumulation characteristics of heavy metals in fishes and crabs in the Yangtze River Estuary, China. *Marine Pollution Bulletin*, vol. 64, no. 6, pp. 1163-1171.

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Assessment of Abundance and Diversity of Bird Species in Andoni Estuary, Niger Delta Region, Nigeria

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Abstract

Birds are feathered indicators of the health of an ecosystem. Changes in the state of an ecosystem result to changes in the number and diversity of bird species. An assessment of the abundance and diversity of bird species in Andoni estuary was conducted between November 2017 and April 2018 in both spring and neap tides. Birds were photographed with Nikon D60 Camera from a 40-horse power outboard ferry at each sampling time lasting six to eight hours. Analysis of variance was employed to determine the significant difference in the number of birds at spring and neap tides while Shannon-Wiener diversity index for species evenness accounts for the degree of evenness of all sampled species. Result showed 49% of birds are found in spring tide, 51% occurred at neap tide and 60% of the total numbers of birds were passerine. Fifty-three species and 6,256 individual birds belonging to 14 taxonomic orders were identified. The Hildebrandt's starling (*Lamprotornis hildebrandti*) least abundant (0.02%) in the sampling was not found in the spring tide whereas the African yellow warbler (*Iduna natalensis*), a tropical small bird, was the most abundant (19.49%) occurring in large numbers in both seasons. An evenness index of 0.3311 indicates that bird species are moderately distributed in the estuary while difference in numbers of bird between tides was not statistically significant. The study concludes that implementation of conservation strategies for birds are needed to sustain bird biodiversity in Andoni estuary.

Keywords: Estuary, diversity, avifauna, human disturbance

Introduction

Ornithology is the study of birds which seeks to know why, how, where and when birds really communicate, reproduce and feed, which are the basic necessities of life (China, 1963). These life styles brought about the diversity (biodiversity) and abundance of organisms within the ecosystem. The identification and classification of birds require adequate knowledge of its morphology, anatomy and physiology which also determines ability of a bird to adapt to its habitat (Bock, 1994). In view of the continuous loss of biodiversity due to pollution, urbanization and environmental changes, studies on the status of birds show data deficiency for many species of birds. Most studies in the Niger Delta region are focused on pollutions from oil and waste, habitat destruction, water quality and rural-urban migration of fishers while birds, whose diversity and abundance are also indices of ecosystem health and productivity, were grossly understudied. According to the Observatoire (2021), birds are often used as indicators to reflect changes in the state of the environment or the ecosystem's health; and are therefore called feathered barometers of the ecosystem (Institute of Bird Populations, 2021). As indicator species, birds provide information on the condition of the ecosystem since they are an integral part of the food chains and food webs.

Materials and Methods

Study Area

Samples of bird species were collected monthly during neap and spring tides from November, 2017 to April, 2018 in the Andoni Estuary. The Andoni Estuary, located in Rivers State in the Niger Delta of Nigeria is situated between latitude 4°28' to 4°45' North and longitude 7°45' East, and empties into the Atlantic Ocean through the Oyorokoto estuary which is the largest fishing settlement in West Africa (NDES, 2003). The aquatic system is brackish in nature and bi-tidal, exposing the mud flats at low tides (Francis, 2003). Komi and Sikoki (2013) reported that the water quality of Andoni River was suitable for aquaculture owing to its physico-chemical properties that are within FAO recommended limits.

Duration and frequency of sampling

Birds were watched at the stretch of the Oyorokoto tributaries of the Andoni estuary from the upper to the lower reaches at each sampling day within a period of six to eight hours as the tide ebbed and flowed using a “40 Horse Power” out-board engine boat (flying boat) for easy accessibility. To minimize escape of birds at the approach of the boat, sometimes the engine is put off while paddles are used to ferry the boat around sampling station. Birds and their nests were observed and photographed. The total number of birds observed were also counted, and recorded accordingly. Birds were identified using the Atlas of Birds and keys described by Naveena and Kumar (2020). The mangrove systems of the sampling site were also observed and photographed. Photographs were taken using a “D60 Nikon” model camera that can take a clear picture of a bird more than 20km from the boat.

Data Analysis

Data collected from the field were subjected to statistical analysis using Analysis of Variance (ANOVA) to determine the variation of bird samples in Neap and Spring tides at Andoni estuary. The Shannon-Wiener biodiversity index was employed to calculate and determine the species richness and species evenness of the study area.

Results and Discussion

The study identified 53 species of birds from 14 taxonomic orders having a total of 6256 individuals. Differences in the number of birds at neap and spring tides was statistically not significant ($p < 0.05$). In a similar study, Sabo (2016) reported 88,105 individual birds belonging to 165 species of 50 families in Hadejia-Nguru wetlands between October and December 2015, the time when the Palearctic migrants have arrived and covered ten wetlands. Calle et al. (2016) reported that changes in abundance of bird species associated with spring–neap tidal cycles occur through mechanisms other than changes to shallow-water availability alone. The report, however, attributed the underlying mechanism in the observed relationship between the abundance of foraging birds and the spring–neap tidal cycle to changes in the availability of prey (i.e. changes in prey density or prey vulnerability to capture) which is closely related to spring–neap tidal cycle itself. Shannon-Wiener diversity index for species evenness (0.3311) indicated that bird species are moderately evenly distributed across the Andoni estuary.

The pelican (*Pelecanus rufescens*) was not recorded in the neap tide. Similarly, the Hildebrandt's starling (*Lamprolornis hildebrandti*) was not found in the spring tide but was least abundant in the sampling (0.02%) during neap tide. According to Hockey et al. (2005), the pink backed pelican (*Pelecanus rufescens*), though, a resident and locally nomadic bird distributed between southwest Arabia and sub-Saharan Africa, moves in response to changes in the wetland conditions. *Lamprolornis hildebrandti*, named after a German collector, Johann Maria Hildebrandt (Beentje, 1998), is a small, country bird found commonly in the woodlands and thornbushes (Craig and Feare, 2009) not coastal areas dominated the *Nypa fructicans* of Andoni estuary.

The African yellow warbler (19.49%), the most dominant bird species in the study are found especially in areas where reeds, overgrown waterside vegetation and forest edges are integrated with wetter vegetations (Borrow and Demey, 2001; *Biodiversity Explorer*, 2016); forages singly or in pairs (Borrow and Demey, 2001), and seasonally flock between July and September in groups of over 50 individual birds.

Table 1: Birds Species of both Spring and Neap Tide of Andoni Estuary

S/N	Birds Species	Birds Species Scientific name	Spring Tide	Neap Tide	Total	Percentage abundance
1	Hamerkop	<i>Scopus umbretta</i>	6	5	11	0.18
2	Giant Kingfisher	<i>Megaceryle maxima</i>	6	4	10	0.16
3	Malachite Kingfisher	<i>Alcedo cristata</i>	14	14	28	0.45
4	Pied Kingfisher	<i>Ceryle rudis</i>	9	8	17	0.27
5	Parrot	<i>Psittacus Erithacus</i>	3	4	7	0.11
6	Long tail cormorant	<i>Phalacrocorax africanus</i>	80	83	163	2.61
7	African darter	<i>Anhinga rufa</i>	92	85	177	2.83
8	Pelican	<i>Pelecanus rufescens</i>	30	0	30	0.48

9	African fish eagle	<i>Haliaeetus vocifer</i>	15	14	29	0.46
10	Osprey (hawk)	<i>Pandion haliaetus</i>	9	5	14	0.22
11	Kite	<i>Milvus migrans, E. caevuleus</i>	31	28	59	0.94
12	Grey heron	<i>Ardea cinerea</i>	44	46	90	1.44
13	Purple heron	<i>Ardea purpurea</i>	16	16	32	0.51
14	Black crowned night heron	<i>Nycticorax nycti corax</i>	19	14	33	0.53
15	Squacco heron	<i>Ardeola ralloides</i>	14	11	25	0.40
16	Black heron	<i>Egretta ardesiaca</i>	56	58	114	1.82
17	Little egret	<i>Egretta garzetta</i>	60	73	133	2.13
18	Great egret	<i>Egretta alba</i>	40	49	89	1.42
19	Green backed heron	<i>Butorides striata</i>	11	10	21	0.34
20	Water thick knee	<i>Burhinus vermiclatsu</i>	163	173	336	5.37
21	Sandpipers	<i>Numenius minutes</i>	192	231	423	6.76
22	White-tailed tropic bird	<i>Phaethon lepturus</i>	20	36	56	0.90
23	Sea ostrich	<i>Osruthio camelus</i>	10	12	22	0.35
24	Ground babblers	<i>Pellorneum ruficeps</i>	71	88	159	2.54
25	Sparrow	<i>Melospiza melodia</i>	4	3	7	0.11
26	Brown-eared Bulbuls	<i>Hypsipetes amaurotis</i>	10	18	28	0.45
27	Grey headed canary flycatcher	<i>Culicieapa ceylonensis</i>	478	576	1054	16.85
28	Dusky created flycatcher	<i>Elminia nigromitrata</i>	400	400	800	12.79
29	African blue flycatcher	<i>Elminia longicauda</i>	4	2	6	0.10
30	White-necked rockfowl	<i>Picathartes gymnocephalus</i>	2	2	4	0.06
31	Dapple throat	<i>Afcumator orostruthus</i>	15	7	22	0.35
32	Thrush nightingale	<i>Remiz pendulinus</i>	15	16	31	0.50
33	Fire-created alethe	<i>Luseinia Luscinia</i>	28	25	53	0.85
34	Brown-chested alethe	<i>Alethe castanea</i>	2	2	4	0.06
35	Isabelline wheatear	<i>Oenanthe isabelline</i>	12	14	26	0.42
36	Starling	<i>Tylo alba</i>	7	3	10	0.16
37	Daurian starling	<i>Agropsar stuminus</i>	9	10	19	0.30
38	Toucan barbet	<i>Semnornis ramphastinus</i>	4	10	14	0.22
39	Hildebrandt's starling	<i>Lamprotornis hildebrandti</i>	0	2	2	0.03
40	Water rail	<i>Rallus aquaticus</i>	71	81	152	2.43
41	Curlew	<i>Numenius americanus</i>	79	85	164	2.62
42	Godwit	<i>Scolopax limosa</i>	90	102	192	3.07
43	Domestic rock pigeon	<i>Columba domestica</i>	2	2	4	0.06
44	Rock dove	<i>Columba livia</i>	11	12	23	0.37
45	Cetti's warbler	<i>Cettia cetti</i>	40	38	78	1.25
46	Cuckoos	<i>Cuculus canorus</i>	5	4	9	0.14
47	Blue jay	<i>Cyanocitta cristata</i>	4	3	7	0.11
48	House crow	<i>Corvus splendens</i>	42	31	73	1.17
49	Magpie	<i>Cyanopica cissa</i>	20	29	49	0.78
50	Common raven	<i>Corvus corax</i>	5	5	10	0.16
51	Swee waxbill	<i>Coccopygia malanotis</i>	62	44	106	1.69

52	Swallow	<i>Hirundo leucosoma</i>	8	4	12	0.19
53	African yellow warbler	<i>Iduna natalensis</i>	606	613	1219	19.49
	Total		3046	3210	6256	100

P<0.05

Conclusion

The study provides a baseline data on the number of birds in the Andoni estuary. Despite the fact that Andoni estuary supports diversity of flora and fauna, there was human disturbances marked by spilled oil films on rivers, plants and other exposed surfaces resulting from illegal refineries (bunkering), oil exploration and exploitation activities. Deforestation motorized marine vehicles, explosives from fishing and bird hunting contributed to limited abundance of bird species. The implication is that the ecological health of the estuary is gradually deteriorating as elements of the coastal food web were negatively affected and the number of resident and migrant species of birds may decline. Based on the findings it is recommended that more ornithological studies be carried out in the Andoni estuary to both update literature and provide in-depth knowledge on the correlation between individual bird species and other factors of the environment as well as to determine the degree of threats posed to avifauna in the locality. Research attention should no longer become exclusively centered on hydrocarbon pollution in the Niger Delta but diversified to include life supported in the estuaries of the delta and necessary policies be implemented for the conservation and mitigation for endangered bird species.

References

- Beentje, H. J. (1998). J. M. Hildebrandt (1847 - 1881): Notes on His Travels and Plant Collections. Kew Bulletin. 53 (4): 835–856.
- Biodiversity Explorer (2016). Chloropeta natalensis (Dark-capped yellow warbler, African yellow warbler). Biodiversity Explorer. Iziko Museums of South Africa. Retrieved 28/06/2021
- Bock, W.J. (1994). History and nomenclature of avian family-group names. *Bulleting of the American Museum of Natural History*. Number 222. New York: American Museum of Natural History. Pp. 113,252.
- Borrow, N. & Demey, R. (2001). *Birds of Western Africa*. A & C Black. pp. 624–625.
- Calle, L., Gawlik, D. E., Xie, Z., Green, L., Lapointe, B. and Strong, A. (2016). Effects of Tidal Periodicities and Diurnal Foraging Constraints on the Density of Foraging Wading Birds. *The Auk*, 133(3):378-396.
- China, W.E. (1963). Direction 105: Brisson, 1760, ornithology: restriction to certain portions of that work of the validation granted under the plenary powers. *Bulleting of Zoological Nomenclature*. 20(5):343-344.
- Craig, A. and Feare, C. (2009). *Family Sturnidae (Starlings)*. In del Hoyo, J., Elliott, A. & Christie, D. (eds.). *Handbook of the Birds of the World. Volume 14: Bush-shrikes to Old World Sparrows*. Barcelona: Lynx Edicions. p. 745.
- Francis, A. (2003). Studies on the ichthyofauna of the Andoni River system in the Niger Delta of Nigeria. Ph.D Thesis, University of Port Harcourt, Nigeria. P. 281.
- Hockey, P. A. R., Dean, W. R. J. and Ryan, P. G. (2005). Roberts - Birds of southern Africa, 7th ed. The Trustees of the John Voelcker Bird Book Fund, Cape Town.
- Komi, G. W. and Sikoki, F. D. (2013). Physico-chemical Characteristics of the Andoni River and its Potential for Production of the Giant Tiger Prawn (*Penaeus monodon*) in Nigeria. *Journal of Natural Sciences Research*. 3(12):83-89.
- Naveena, M and Kumar, G. H. (2020). Classification of Birds Using KNN and SVM Classifier. *International Journal of Computer Science Issues* 17 (1): 27-31. DOI:10.5281/zenodo.3987114
- Niger Delta Environmental Survey (NDES) (2003). Phase 1 report on the Niger Delta Environment.
- Observatoire (2021). Vulnerable Bird Species and Bird Concentrations in Upper Niger Basin and Inner Niger Delta. Retrieved from <https://onisdin.info/administrative-borders/Plone/en/ecosystems-biodiversity/birds>
- Sabo, B. B. (2016). Checklist of Bird Species at the Hadejia-Nguru Wetlands, Nigeria. *Global Advanced Research Journal of Agricultural Science*, 5(11):405-412.

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Abundance and distribution of the Periwinkle species *Pachymelania fusca* (Gmelin, 1791) of the Intertidal Mudflats of Calabar River

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Abstract

Studies on the abundance and distribution of *Pachymelania fusca* along the intertidal mudflats of Calabar River was carried out between July and September, 2020. Live periwinkles were sampled once a month from three stations and transferred to the laboratory for identification, grouping and enumeration. Results of analysis of variance revealed no significant differences ($p>0.05$) in the abundance of monthly and grouped samples. Average distribution of smooth periwinkles in the three stations were 81.00 (1.91%), 705.67 (16.62%) and 2146.33 (50.545); for partially wrinkled 72.67 (1.71%), 61.00 (1.44%), 433.33 (10.20%) while fully wrinkled samples were 49.67 (1.17%), 264.00 (6.22%), 433.00 (10.20%) respectively. There was significant difference in the distribution of periwinkle sampled which was attributed to anthropogenic activities within the river. The abundance and distribution of periwinkle in all the groups follow the same pattern of station3>station2>station1.

Keywords: Periwinkles, *Pachymelania fusca*, Intertidal, Smooth, Wrinkled

Introduction

Pachymelania fusca is a genus of gastropod mollusk in the order Sorbeoconcha and family Thiariidae. This family is represented in the lagoons, estuaries and mangrove swamps by two genera (*Pachymelania* and *Tympanotonus*) and are usually harvested by handpicking (Adebayo *et al.*, 2011). *Pachymelania fusca* are not often found in the main body of water but are restricted to the mangrove swamp and mudflats. Its distribution frequently coincides with that of the *Tympanotonus fuscatus* and the two grouped together are called periwinkles in Nigeria (Egonmwan, 2007). Periwinkles constitute one of the relatively easily harvested shell fishes occurring widely within the upper intertidal zone of coastal areas. Bob-Manuel (2012) observed that *T. fuscatus* occurs in the littoral habitat while *P. fusca* colonize the subtidal and mud beaches. They affect benthic community structure and recruitment success of structurally important seaweeds (Trussell *et al.*, 2004). In view of the wide exploitation of periwinkle species due to their economic importance, there is need to assess their abundance and distribution on the intertidal mudflat of Calabar River to ascertain their ecological status.

Materials and methods

The study areas are located between latitude 04°30'13" N and longitude 08°30'06" E; and latitude 04°32'40"N and longitude 08°28'40"E. samples of periwinkle were collected once a month for three months from July to September, 2020 by hand picking them along the mudflats of the Calabar River at the different sampling stations. The samples collected were stored in three sampling containers of ten-liter capacity each, labelled according to the sampling point and transported to the Institute of Oceanography Laboratory University of Calabar for identification. The samples were identified based on taxonomic guidelines of Bouchet and Pocroi (2005). The identified samples were separated into three different groups depending on the smoothness or wrinkling of the shell and then grouped as; "**smooth**", "**partially wrinkled**" and "**fully wrinkled**" in each station. Individual periwinkle grouped were counted and recorded according to the taxonomic group they belong. The relative abundance and distribution of each group was calculated respectively for each month and station according to the formula given by Jamabo and Alfred-Ockiya (2000) below:

$$\%RA = \frac{n(100)}{N} \text{ where } n \text{ is the number of a particular group, } N \text{ is total number of all individuals of a}$$

all groups and %RA is the relative abundance in percentage

Data obtained from the study were subjected to descriptive statistics for means, standard deviation and standard error of mean. ANOVA was used to test the significant variations in abundance and distribution of periwinkles between the three sampling stations. Variations with a probability level of $p<0.05$ was considered significant and further subjected to Duncan Multiple Test of difference to specify the source of variation.

Results

The periwinkle species distribution and abundance are presented in Table 1-4 below. Based on morphological identification, three varieties of periwinkle (*Pachymelania fusca*) were observed on the mudflat of Calabar River. These varieties were grouped into “smooth”, “partially wrinkled” and “fully wrinkled” respectively.

Table 1: Frequency distribution and abundance of periwinkle identified during the study

Months	Groups	S1	S2	S3	Total
July	Smooth	62	517	1915	2494
	Partially wrinkled	56	30	401	487
	Fully wrinkled	33	211	357	601
Total		151	758	2673	3582
August	Smooth	52	562	1842	2456
	Partially wrinkled	58	55	377	490
	Fully wrinkled	29	218	423	670
Total		139	835	2642	3616
September	Smooth	129	1038	2682	3849
	Partially wrinkled	104	98	522	724
	Fully wrinkled	87	363	519	969
Total		320	1499	3723	5542

Table 2: Percentage distribution and abundance of periwinkle identified during the study

Months	Groups	S1	S2	S3	Total
July	Smooth	1.73	14.43	53.46	69.63
	Partially wrinkled	1.56	0.84	11.19	13.60
	Fully wrinkled	0.92	5.89	9.97	16.78
Total		4.22	21.16	74.62	100.00
August	Smooth	1.44	15.54	50.94	67.92
	Partially wrinkled	1.60	1.52	10.43	13.55
	Fully wrinkled	0.80	6.03	11.70	18.53
Total		3.84	23.09	73.06	100.00
September	Smooth	2.33	18.73	48.39	69.45
	Partially wrinkled	1.88	1.77	9.42	13.06
	Fully wrinkled	1.57	6.55	9.36	17.48
Total		5.77	27.05	67.18	100.00

Table 3: Average monthly abundance of periwinkle species identified during the study

Groups	July Freq. (%)	August Freq. (%)	Sept. Freq. (%)	Total Freq. (%)
Smooth	831.33 (19.77%)	818.67(19.47%)	1283.00(30.51%)	2933.00 (69.74%)
Partially wrinkled	162.33 (3.86%)	122.50 (2.91%)	241.33 (5.74%)	526.17 (12.51%)
Fully wrinkled	200.33 (4.76%)	223.33 (5.31%)	323.00 (7.68%)	746.67 (17.75%)
Total	1194.00 (28.39%)	1164.50 (27.69%)	1847.33 (43.92%)	4205.83 (100.00%)

Table 4: Average spatial distribution of periwinkle species identified during the study

Groups	S1 Freq. (%)	S2 Freq. (%)	S3 Freq. (%)	Total Freq. (%)
Smooth	81.00 (1.91%)	705.67(16.62%)	2146.33(50.54%)	2933.00(69.07%)
Partially wrinkled	72.67 (1.71%)	61.00 (1.44%)	433.33 (10.20%)	567.00 (13.35%)
Fully wrinkled	49.67 (1.17%)	264.00 (6.22%)	433.00 (10.20%)	746.67 (17.58%)
Total	203.33(4.79%)	1030.67(24.27%)	3012.67(70.94%)	4246.67(100.00%)

Discussion

The distribution and abundance of the periwinkle species, *Pachymelania fusca* obtained from the mudflats of Calabar River at different sampling stations revealed significant spatial difference. This variability could be attributed to different ecological characteristics of the mudflats. The different stations are also subjected to different anthropogenic influence, as such the abundance and distribution are affected differently. This result is in line with

the previous study of Ekpo *et al.* (2015) who reported that periwinkles are bottom feeders and tend to be more abundant under roots and decaying mangroves. This ecological characteristic is typical of sampling stations (3), where most of the periwinkle samples were picked under the roots and decaying mangrove plants during low tide. Other factors such as salinity, water depth, currents and nature of bottom deposits were highlighted by Bob-Manuel (2012) to affect their distribution in the coastal areas of West Africa. The abundance of periwinkle samples on the mudflat of station 3 was also reaffirmed by the study of Ajao and Fagade (1990) who observed the greatest densities of periwinkles at site farther from anthropogenic inputs of sewage and industrial effluents and in sediments containing 6-40% silt –clay. The results of the present work also agree with that of Saier, (2000) which reported that periwinkles can respond to differences in microhabitats and change their behavior in response to different environmental conditions including physiochemical parameters of habitat water. However, notwithstanding the levels of anthropogenic activities within the study area, periwinkles were still recorded in reasonable densities. The reason could be attributed to the ability of the periwinkles to contract faster and deeply up to $\frac{3}{4}$ into the shell and maintain a healthy condition in adverse periods as reported by Dambo, (1993) when compared with *P. aurita*. For all the periwinkle groups, this trend was maintained throughout the study: Station 3 > station 2 > station 1. It was also revealed that the monthly abundance and spatial distribution did not depend on the group of periwinkle as different periwinkle groups be it smooth or wrinkled followed the same pattern of abundance and distribution.

Recommendations

Based on the finding of this study, the following are recommended:

1. Discharge of untreated effluents into the river should be checked.
2. Indiscriminate deforestation of mangrove which are natural habitat for periwinkle should be avoided.
3. Anthropogenic activities such as sand mining and dredging which could disrupt the periwinkle habitats should be curtailed.
4. Taskforce should be initiated to monitor the activities of the inhabitants of the coastal region with this the rate of aquatic pollution will be reduced while enhancing biodiversity.

References

- Adebayo, B.C., Onilude, A.A. and Etuk, F.J. (2011). Studies on microbiological, proximate, mineral and heavy metal composition of fresh water snails from Niger Delta Creek in Nigeria. *Assumption Uni J Technol*, 14 (4), 290-298.
- Ajao, E.A. and Fagade, S.O. (1990). Production and population dynamics *Pachymelania aurita* Muller Arch. *Hydrobiol.* 120 (1): 97-109.
- Bob-Manuel, F.G. (2012). A preliminary study on the population estimation of the periwinkles *Tympanotonus fuscatus* (Linnaeus, 1758) and *Pachymelania aurita* (Muller) at the Rumuolumeni mangrove swamp creek, Niger Delta, Nigeria. *Agric. Biol. J. N. Am.*, 3(6): 265-270.
- Bouchet, P. and Pocher, J.P. (2005). Classification and nomenclature of gastropod families. *Malacologia: International Journal of malacology*, 47(1-2), 300-397.
- Dambo, W.B. (1993). Tolerance of the periwinkle *P. aurita* and *T. fuscatus* to refined oils. *Environ Pollution*. 79: 293-296.
- Egonmwan, R.I. (2007). The reproductive cycle of the mangrove Prosobranch, *Pachymelania fusca* in Lagos, Nigeria. *Pakistan journal of Biological Sciences*, 10: 649-653.
- Ekpo, E.A., George, U. U., Edet, M. (2015). Impacts of water pollution with heavy metal on the tissue of *Egeria radiata* (Bivalve: Tellinacea: Donacidae) (Lammark, 1804) obtained from Calabar River, Cross River State, Nigeria. *Nature and Science*, 13(8); 36-39
- Jamabo, N.A. and Alfred-Ockiya, J.F. (2000). *Tympanotonus fuscatus*-its potential and abundance in the mangrove swamps of the upper Bonny River, River State, Nigeria. 693-695.
- Saier, B. (2000). Age-dependent zonation of the periwinkle *Littorina littorea* (L.) in the Wadden Sea. *Helgol Mar Res.* 54: 224-229.
- Trussell, G. C., Ewanchuk, P.J., Bertness, M.D. and Silliman, B.R. (2004). Trophic cascades in rocky shore tide pools: distinguishing lethal and non-lethal effects. *Oecologia*. 139: 427-432.

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Reproductive Ecology and Domestication of Silver Catfish, *Chrysichthys nigrodigitatus*, of the Cross River

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Abstract

Chrysichthys nigrodigitatus, commonly known as silver catfish, is a prized food fish in Nigeria. It occurs in several African rivers. In the Cross River system, it occurs all year round with peak in the rainy season, from April to October. Several studies have reported on some threatening factors to the species' survival, including overfishing, low genetic diversity and climate change. The proposed method to curb the depletion of these specie resources is domestication. Studies were conducted to determine the reproductive ecology of the species. Simulation of these ecological factors in the hatchery for possible domestication of the species was carried out. Results showed that the species is a freshwater species with salinity range from 0.01-0.06 ppt. Their preponderance was directly correlated with turbidity and indirectly corelated with transparency, showing that they prefer dark and shaded conditions. Rainfall triggered reproductive activities. Spawning occurred within the rainy period in crevices and holes in the rocky substratum of the river bed. We simulated these conditions in the hatchery and fish farm by placing cylindrical pipes as holding receptacles in the ponds. This provided hiding place and shade for them. Spawning inside the receptacles was observed in the month of June through September, coinciding with the phenomenon in the wild. The species is shown to embark on parental care. The male parents carry the brood in their mouths until they were able to fend for themselves. Thus, understanding the reproductive ecology of *Chrysichthys nigrodigitatus* in the Cross river, enabled us to develop protocol that assisted in its domestication. This is the first time *Chrysichthys nigrodigitatus* has been raised in the hatchery and made to spawn in captivity. Thus, our work has expanded the aquaculture range in Nigeria and Africa.

Keywords: Ecology, Fish, Aquaculture, *Chrysichthys nigrodigitatus*, Cross River

Introduction:

Chrysichthys nigrodigitatus, commonly known as silver catfish, is a prized food fish in Nigeria. The species is widely distributed in freshwater of West Africa, where they are valued in human nutrition (Holden, 1991). According to Paugy *et al.* (2003), *Chrysichthys* is found in Nile, West Africa and western coast of Central Africa. In the Cross River system, east of Niger Delta, the species occurs all year round with peak in the rainy season (Ama-Abasi *et al.*, 2019); here the species forms the mostcommercially important single species fishery, providing employment opportunity for the teeming populace. In the Cross River estuary, the species is the third most important species after bonga and croaker (Holzloehner, *et al.*, 2007).

However, the species is listed in the IUCN list of threatened species (Da Costa, 2010). Recent researches have also shown declining population of the species due to overfishing (Ama-Abasi and Uyoh, 2020) and possible impacts of climate change, Ama-Abasi, *et al.* (2019). Adilieje *et al.* (2020) and Uyoh *et al.* (2020) demonstrated that *Chrysichthys nigrodigitatus* of the Cross River has low genetic diversity with the potential of spontaneous wiping out of the population in the face of environmental variability.

Such trends may predispose the species to decline. To shield the species from the vagaries of climate change and overfishing, there is need for domestication of the species. Domestication will not only shield the species from the vagaries of climate change but will lead to expansion of aquaculture in the continent. Hitherto, the aquaculture of the species was not considered because of the erroneous belief and misconception that the species is estuarine and so needs saltwater for its growth. Ordinary observation has it that the species is preponderant in the freshwater of the Cross River in the rainy season. So, the theory of being estuarine was an enigma (Ama-Abasi *et al.*, 2019). This study was conducted to establish the reproductive ecology of *Chrysichthys nigrodigitatus* and to also attempt its domestication, based on the ecological findings.

Materials and Methods

Study Area: Studies on the reproductive ecology was conducted in the Cross River system. The Cross River is the main river in southeastern Nigeria. It originates from the Cameroon mountains and flows through the rainforest area westward before meandering southward through the mangrove vegetation and finally emptying its water in the Atlantic Ocean at the Bight of Biafra. The River is located between latitudes $4^{\circ} 34.59'$ and $5^{\circ} 87' N$ and longitudes $8^{\circ} 59.9'E$ and $7^{\circ} 24.3'E$. The river basin and its catchment are characterized by dry season from November to March and wet season from April to October. The main occupation of the people includes fishing, hunting, farming and boat making.

Sampling Procedure: The river was divided into the upstream and downstream sections for the purpose of this study (Fig 1). Surface water and fish samples were collected fortnightly at neap tide and spring tide from January 2017 to December 2017 at three locations along the length of the Cross River between Akani Obio Uruan (downstream) and Ikot Okpara (upstream) (Fig 1). The fishers used gillnet, drums and dragnet as their fishing gears. Fish catch were randomly sampled from five to ten boats and both the total catch and catch -per-unit effort were estimated from such samples.

In situ physico-chemical parameters such as surface temperature, conductivity and water depth were taken while water samples were collected in sterilized containers in iced cold boxes and transported to the analytical laboratory of Institute of Oceanography, University of Calabar for turbidity analysis using turbidimeter. Other parameters were analyzed using standard analytical methods for water analysis (Eaton and Franson, 2005). Temperature was measured using mercury in glass thermometer, transparency was measured using Secchi disk, electrical conductivity was obtained using VOLTCRAFT WA-100ATC. Rainfall data were collected from the meteorological unit of Geography and Environmental Science Department of the University of Calabar. River depth was measured by the use of echo sounder. Fish catch and abundance were measured using top-loaded Sertoli balance in kg while the catch per unit effort was calculated as total catch per number of fishing boats. Reproductive behaviour was monitored by depending on the indigenous knowledge of the local fishers, majorly using their fishing gears to understand the species' reproductive strategies.

Once the reproductive strategies were understood, the conditions were simulated in fish pond of the Institute of Oceanography, University of Calabar. Spawning receptacles made of pvc pipes of 15cm diameter were placed in fish pond of Institute of Oceanography Fish Farms. The pond is made of subterranean water which increases in volume during the rainy season. The size of the pond was 24 m X 100 m. There is a control valve at one end which allows excess water to flow out from the pond. Water grass and other aquatic weeds like waterlily grow in the pond making it semi-natural. Fifty specimens of *Chrysichthys nigrodigitatus* comprising both males and females were introduced into the pond. The fish depended on *Tilapia* which formed part of the fish community as their staple and were not fed with any extraneous food. Critical water parameters of temperature, conductivity, pH and dissolved oxygen were monitored weekly. Temperature and dissolved oxygen were measured using dissolved oxygen meter, electrical conductivity was obtained using VOLTCRAFT WA-100ATC. pH of the water was measured using the pH meter with model PHT-01ATC. Fish weight measured using top-loaded Sertoli balance in grams. The spawning receptacles were monitored fortnightly in order to recover any spawning fish or hatchlings in the receptacles.

Once the hatchlings were recovered from the ponds, they were taken into the hatchery darkroom for further management and growth. In the darkroom there was a simulation of the critical parameters to enable *Chrysichthys nigrodigitatus* to survive and demonstrate the possibility of domestication. The hatchlings were raised in 1 X 1m plastic container with water volume of 1500 litres. Constant oxygen was supplied throughby AquaOxy2000 oxygen pump capable of supplying 2000 litres of oxygen per hour. The fry were fed with coppers and their growth monitored monthly by measurement of total length and weight. To maintain high hygienic condition and prevent disease infection, the water was changed every three day.

Statistical Analysis: All data obtained for the ecological studies were subjected to descriptive statistics for mean, $\pm$ standard error. Correlation analysis was used to test any relationship between the ecological variables and fish catch across months (January to December). Relationship between environmental/ecological variables and fish distribution and abundance were determined using simple linear correlation. Simple linear regression analysis was also done to standardize the relationship between rainfall and fish catch and the environmental variables. All statistical analyses were performed using the Prism GraphPad 5 (GraphPad software, La Jolla, USA).

Results and Discussion

The ecological variables of rainfall, turbidity, transparency, temperature and conductivity shows some correlation with the fish catch/abundance (Fig 2).

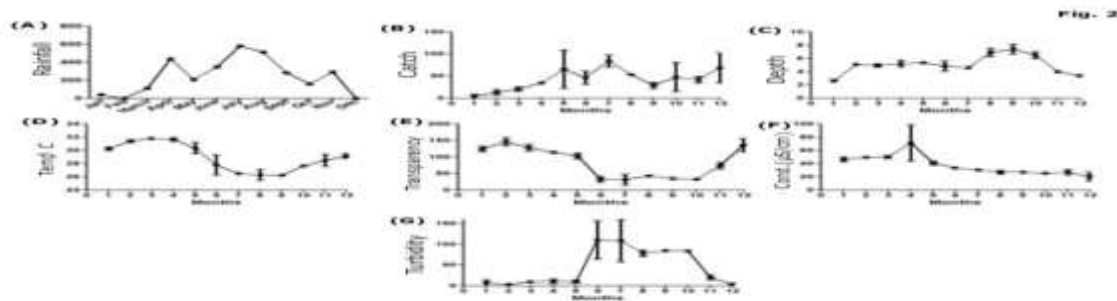


Fig 2: Time series of ecological parameters and *Chrysichthys* catch over the study period.

The salinity values ranged from 0.01 to 0.06.(Table 1). These values show that the *Chrysichthys nigrodigitatus* is a freshwater species. This is in corroboration with Holden (1991) that the species inhabits the freshwater of West Africa, Nile and Central Africa. This is in contrast to the view Sivalingam (1975) who opined that the species is brackish water. Consequently, the aquaculture of the species can be explored in the freshwater. Correlation analysis established a relationship between environmental variables and fish catch (Table 2). A positive and highly significant ($P<0.01$) relationship was observed between sampling months and fish catch (0.542); also, a negative and highly significant ($P<0.01$) relationship was observed between temperature and sampling months (-.610); fish catch and conductivity (-0.522). Linear regression analysis established the relationship between fish total catch and mean weekly rainfall with regression model of $Y=12.8+0.098x$, showing that there is a positive relationship between fish total catch and rainfall. The highly significant correlation between the months of the year and fish abundance reveals that the species is seasonal. The highly significant negative correlation between temperature and sampling months also is an indication of negative influence of temperature on fish catch. A strong linear relationship between fish abundance and rainfall presents a lot of implications on fish abundance and distribution in relation to climate change. Ama-Abasi *et al* (2019) and Ama-Abasi and Uyoh (2020) reported that rainfall initiates the reproductive events. Moses (2001) opined that reproduction during the rainy season makes use of the habitat expansion and food availability for the juveniles which also depends on allochthonous food source at this time. From Fig 2 A, Band D, the period of peak *Chrysichthys* abundance coincided with peak rainfall and lowest temperature.

Table 1. Correlational matrix of environmental variables and *C. nigrodigitatus* catch from the Cross River, Nigeria

	Months	Catch	Trans	Tur	Temp	Depth	cond	rainfall
Months	1							
Catch	.542**	1						
Trans	-.473*	-0.404	1					
Tur	0.373	0.32	-.900**	1				
Temp	-.610**	-.427*	.769**	-.753**	1			
Depth	0.135	0.179	-.463*	.477*	-0.299	1		
cond	-.885**	-.522**	.528**	-.432*	.692**	-0.189	1	
rainfall	0.182	.488*	-	.672**	-.482*	0.316	-0.169	1
			0.658**					

Transp = transparency; Tur = turbidity; Temp=temperature, cond= conductivity. * Asterisks shows significant correlation. ** Highly significant correlation.

A relationship of fish catch to climatic factors like temperature and rainfall, means that in the face of climate change, *Chrysichthys nigrodigitatus* fishery can be adversely affected with decline in population and possible eradication of the source of livelihoods of millions of the riverine communities in Niger Delta and elsewhere in Nigeria and Africa, whose livelihood depends on the fishery.

The negative correlation between fish abundance and transparency implies that the species is sensitive to light and that is why they prefer turbid waters which provide some level of shading from light. This also is possible reason they hide in holes and crevices and the pipes which the fishers use as trap.

The reproductive strategy of the fish ensures that they spawn during the rainy season inside Indian bamboo and rock crevices (Plate 1). This ensures that sperms is not wasted and the male can easily pick the eggs into its mouth for brooding and safety.

We therefore adopted this techniques in the pond and provided a condition for the fish to spawn by placing the pipes in the ponds(Plates 2)



Plate 1: A species of *Chrysichthys* trapped inside Indian bamboo.(Several pairs of *Chrysichthys* were recovered in Indian bamboos and drums which the fishers used as their trap).



Plate 2: Several spawning receptacles in the pond.



Plate 3: Male *Chrysichthys* inside the spawning receptacle



Plate 4: Male and female *Chrysichthys* recovered from the spawning receptacle and their fry

With the supposition of potential climatic impacts on the fisheries, there is need to pursue the domestication of *Chrysichthys nigrodigitatus* as an adaptation to climate change impacts. This is why we attempted the domestication of the species. The simulations of the environmental conditions in the ponds including the use of pvc pipes as spawning receptacles (Plate 2) proved *Chrysichthys nigrodigitatus* population is significantly influenced by rainfall and temperature, two climatic factors that can have adverse effects on the fish and its fisheries in the face of climate change. Domestication of the species has been achieved with high prospect for aquaculture expansion in Africa. To shield the species from the vagaries of climate change and overfishing, the aquaculture of the species should be vigorously pursued. This has the potential of increasing Nigerian businesses and reducing poverty, thus fulfilling the SDG.14.

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References

- Adelieje, C., Uyoh, E.A., Ntui, V.O. Ama-Abasi, D. (2020): Morphological and Genetic Diversity Studies of *Chrysichthys nigrodigitatus* from the Cross River, Nigeria, Using Microsatellite Markers. *Ann Res. & Rev. Biol.* 35(5): 42-52,
- Ama-Abasi, D. and Uyoh, E. (2020): Ecology and population dynamics of silver catfish, *Chrysichthys nigrodigitatus* (Siluriformes: claroteidae) of the Cross River, Nigeria. *Global Journal of Agricultural Science.* 19:71-82.
- Ama-Abasi, D.E., Udo, M.T., Uyoh, E.A., Job, B.E., Edide, J.E., Uwalaka, S. (2019): The migration status of Silver catfish. *International Journal of Fisheries and Aquatic Studies* 7(5): 536-541.
- da Costa, L. M., Abdelhamid, A. Lalaye, P., and Moelants, T. (2010). *Chrysichthys nigrodigitatus*. The IUCN Red list of Threatened Species: e.10.2305/IUCN.UK.2010- 3.RLTS.T182997A801953.en Down loaded on 20 April 2020.
- Holden, M., Reed, W. (1991) : West African freshwater fish. Singapore Longman Publishers Ltd; 1991.
- Holzloehner, S., Enin, U.I., Ama-Abasi, D., Nwosu, F.M. (2007) : Species composition and catch rates of the gillnet fishery in the central Cross River Estuary, S.E. Nigeria. *Journal of Afro-tropical Zoology.* 2007;107-112.
- Sivalingam S., 1975: The biology of cultivable brackishwater and marine finfish in Africa – 28 Symposium on aquaculture in Africa, Accra, Ghana. CIFA/IA (Suppl. 1), 204-291
- Uyoh, E.A., Ntui, V.O., Ibor, O.R., Adilieje, C.M., Udo, M., Opara, C., Ubi, G.M., Ama-Abasi, D. (2020): Molecular characterization of two catfish species (*Chrysichthys nigrodigitatus* and *Chrysichthys auratus*) from the Cross River, Nigeria, Using Ribosomal RNA and Internal Transcribed Spacers. *Annual Research & Review in Biology* 35(2):13-24.

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Ichthyofaunal Composition Of A Tropical Rainforest River In Akwa Ibom State, Southern Nigeria

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Abstract

Fish species composition of Qua Iboe River at Onna Bridgehead in Ikot Enwang, Onna L.G.A. was investigated for seven months using standard analytical methods. Results obtained showed a total of 462 fish specimens consisting of 12 species, 11 genera and 8 families. Family Cichlidae had highest (193 specimens; 41.78%) number of individuals while Cyclopsettidae was the least (1 specimen; 0.22%). *O. niloticus* (161 specimens; 34.85%) was the most abundant fish species whereas *C. stampflii* (1 specimen; 0.22%) was the least abundant species. The smallest species in terms of total length was *Citharichthys stampflii* (1.19cm) while the largest was *Oreochromis niloticus* (3.5-25.70cm; 9.61±2.49). In terms of total weight, the lightest and heaviest species was also *Oreochromis niloticus* (1.20–332.90g; 22.70±28.37). Six species showed significant contributions while six others made insignificant contributions to the fishery based on Index of Preponderance. A greater number of the fish had condition factor less than 1; signifying low condition while high body condition was recorded in 5 species. Ten out of the 12 species showed negative allometric growth ($b < 3$) except *B. longipinnis* that exhibited positive allometric growth ($b > 3$). Negative allometric growth pattern recorded in almost all the species could be attributed to intense fishing pressure, therefore there is need to introduce fishery management techniques to regulate the fishing activities for sustainability.

Keywords: ichthyofaunal composition, specimens, abundance, Onna Bridgehead, Ikot Enwang, Qua Iboe River

Introduction

Any life form in water is often considered as food for man and is usually referred to as fish; composing shellfishes, finfishes, plants and animals. Fish has been one of the primary components of man's diet and it is an essential nutrient source, especially of highly edible proteins. Fish constitutes the major source of animal protein in Africa. It has the most balanced amino acid profile and its consumption cuts across all religious and cultural barriers; the reason for its very high demand (Bolarinwa *et al.*, 2015). Nigeria has a rich variety of fish faunal resources, which over the decades could not be conveyed to increased domestic fish output due to disregard to law of the sea security issues, environmental pollution, erratic policy changes of the government and lack of implementation. Therefore, for the sustainability of these resources, an adequate knowledge of species composition, diversity and its relative abundance in their native habitats are essential (Adaka *et al.*, 2016). Fish communities are considered indicators of aquatic ecosystem health despite their high degree of natural variability.

The impact of pollution and other human activities on aquatic biodiversity cannot be overemphasized. Condition factor of fish species may be an indicator reflecting the interactions between biotic and abiotic factors to the physiological condition of fish, being assumed that heavier fish shows a healthier physiological state (Stavrescu-Bedivanet *et al.*, 2015). In addition, analyzing the size structure of a fish population could reveal many ecological and life-history traits, such as the ecosystem health or stock conditions. Even a basic description and length distribution of fish population has a great value for reference as well as for comparison in terms of surveillance (FAO, 2018). Morphometric characteristics can be used to assess the influence of environmental factors of fish populations (Omoniyet *et al.*, 2002). Growth in fish is in length and in bulk (King, 1995). Thus, length weight relationships of fishes are important in fisheries biology because they allow interrelated estimation of average weight of fish of a given group or population (Bolarinwa and Popoola, 2013).

There is dearth of scientific information on this all-important aquatic ecosystem traversing Onna L.G.A. at the Bridgehead. Despite the important commercial and economic fish species often seen, they are not documented anywhere. Landings and related fisheries' activities seem to be on decline when compared to the past. Also, the river is faced with many human anthropogenic perturbative activities which may pose a considerable risk to the quality

and health of the fishes as well as their consumers. Thus, this paper aimed at presenting a benchmark data by investigating on the fish species composition in Qua Iboe River at the Onna Bridgehead in Ikot Enwang, Onna L.G.A.

Materials and methods

Description of the Study Area

The study was carried out in the Qua Iboe River at Onna Bridgehead in Ikot Enwang (Fig. 1), Onna L.G.A. of Akwa Ibom State, Nigeria. The river flows downstream into Eket L.G.A. and empties into the Atlantic Ocean in Upengang, Ibeno. It lies within the tropical rainforest region with a mean annual temperature of about 30°C and a relative humidity of 74%. The human activities observed were bathing, laundry, open defecation, washing of motor bikes, refuse dumping, timber-logging and intense fishing activities. The main sampling points were located at the right and left sides of the Bridgehead.

Fish sampling, preservation and measurement

Fish specimens caught were procured from the artisanal fishers and middlemen at the sampling sites for seven months (between the months of October 2018 and April 2019). Fishing gear employed were the set gillnets while the cast nets were thrown in the open water in each sampling site. Randomly sampled fish specimens were transported to Fisheries Laboratory in the Department of Fisheries & Aquatic Environmental Management, University of Uyo, Annex Campus, Uyo. They were preserved in 10% diluted formaldehyde solution in well-labeled containers to reduce microbial digestion to the minimum (Ekpoet *et al.*, 2012a, b). All preserved samples were removed from the formaldehyde solution, rinsed in clean water and placed slanting with the mouth down to drain out excess fluid for about 5-10 minutes prior to identification.

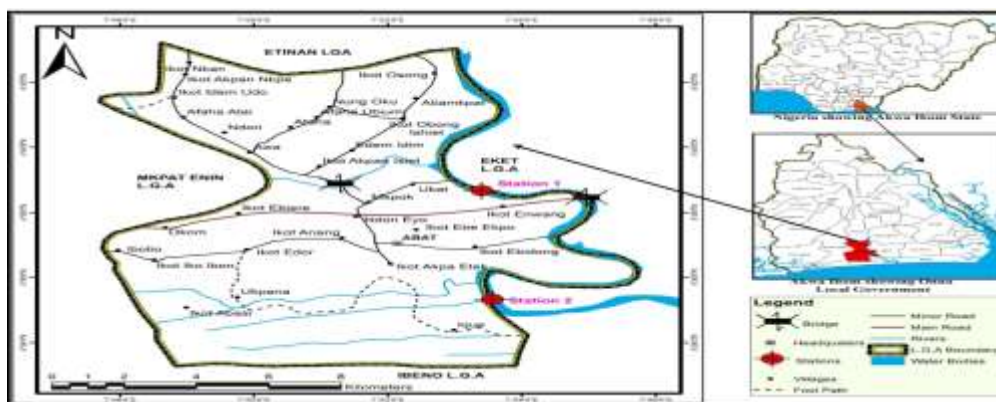


Fig. 1: Map of Onna L.G.A. showing the sampling stations in Qua Iboe River (Insert: Maps of Nigeria and Akwa Ibom State)

Specimens were identified from family to species levels with the aid of identification keys such as FAO (1990); Olaosebikan and Raji, (2004); and Idodo-Umeh (2005). Each specimen was measured to the nearest 0.1cm total length (TL, cm) and also weighed to the nearest 0.1g total weight (TW, g) using a top-loading Triple Beam (MB-2610) (0.1–610g) balance.

Data analyses

Statistical analysis of the pooled raw data generated for fish samples such as descriptive statistics, correlation analysis (*r*) and one-way analysis of variance (ANOVA) at 0.5 probability level were carried out.

Condition factor (K)

The monthly condition factor or wellbeing (K) of the fish species was computed using the relationship for isometric growth from Gayanilo and Pauly (1997) equation:

$$K = \frac{W_t}{L^3} \times 100 \text{ ----- (1)}$$

Where: W_t = Weight of fish (g); L = Total length of the fish (cm)

Condition factor values equal to or greater than one (≥ 1) was considered as high while those less than one (< 1) was considered as being low.

Length-weight relationship (LWR)

Relationship between the length and weight of each species was estimated using the equation:

$$W = aL^b \text{----- (2)}$$

Where: W = Weight of the fish in g; L = Total length of the fish in cm; a = Exponent describing the rate of change of weight with length (the intercept of the regression line on the Y-axis) and b = the slope of the regression line (also referred to as the allometric coefficient).

The data on total length and total weight were linearized by a logarithmic transformation to give:

$$\text{Log } W = \text{Log } a + b \text{ Log } TL \text{----- (3)}$$

Where: a = constant and b = slope

Abundance and occurrence of fish species using Index of Preponderance

Pooled data of catches in each sampling station was used in assessing the Index of Preponderance (IP) which was expressed as:

$$IP (\%) = \frac{\% N. \% W}{\Sigma (\% N. \% W)} \times 100 \text{----- (4)}$$

Where: N = Number of fish species and W = Weight of fish species (g)

Fishes with IP (%) values of less than ($<$) 0.50 were regarded as being of relative insignificant contributions while those with values greater than ($>$) 0.50 were considered as being of significant contributions. IP expressed the percentages of the total number and total weight of fish caught.

Results

Biometrics, abundance and size of fish species in Qua Iboe River at Onna Bridgehead, Nigeria

The result of the morphometric parameters of fishes sampled from Qua Iboe River at Onna Bridgehead are presented in Table 1. A total number of 462 fishes were sampled; consisting of 12 species (*Brycinus longipinnis*, *Citharichthys stampflii*, *Chrysichthys nigrodigitatus*, *Neochelon falcipinnis*, *Monodactylus sebae*, *Oreochromis niloticus*, *Parailia pellucida*, *Pellonulaleonensis*, *Schilbemystus*, *Coptodon guineensis*, *C. zillii* and *Pelmatolapia mariae*); 11 genera and 8 families.

In terms of relative abundance, the family Cichlidae had highest (193 specimens; 41.78%) total number of individuals sampled while Cyclopsettidae was the least (1 specimen; 0.22%). *O. niloticus* (161 specimens; 34.85%) was the most abundant fish species while *C. stampflii* (1 specimen; 0.22%) was the least abundant species.

The smallest fish species in terms of total length was *Citharichthys stampflii* (1.19cm) while the largest was *Oreochromis niloticus* (3.5-25.70cm; 9.61 ± 2.49). In terms of total weight, the lightest and heaviest fish species was also *Oreochromis niloticus* (1.20–332.90g; 22.70 ± 28.37).

Table 1: Sample size (N), range and mean values of total length and total weight of fishes sampled in Qua Iboe River at Onna Bridgehead, Nigeria

Fish family	Fish species composition	N	Total length (cm)		Total weight (g)	
			Range	Mean±SD	Range	Mean±SD
Alestidae	<i>Brycinus longipinnis</i>	75	5.5–10.10	8.00±1.17	2.70–16.70	7.95±4.08
Total Alestidae		75				
Cichlidae	<i>Coptodon zillii</i>	9	9.40–21.00	12.91±3.41	11.59–42.20	25.71±10.74
"	<i>" guineensis</i>	20	8.60–24.00	15.21±5.04	13.37–284.10	125.29±88.26
"	<i>Pelmatolapia mariae</i>	3	20.10–24.00	22.50±2.10	260.20–280.70	270.50±10.25
"	<i>Oreochromis niloticus</i>	161	3.50–25.70	9.61±2.49	1.20–332.90	22.70±28.37
Total Cichlidae		193				
Monodactylidae	<i>Monodactylus sebae</i>	16	8.90–17.50	14.25±2.39	11.50–231.90	61.41±71.66
Total Monodactylidae		16				
Cyclopsettidae	<i>Citharichthys stampflii</i>	1	1.19	1.19	19.0	19.0
Total Cyclopsettidae		1				
Claroteidae	<i>Chrysichthys nigrodigitatus</i>	12	7.00–18.00	11.10±3.23	2.50–43.50	16.00±10.61
Total Claroteidae		12				
Schilbeidae	<i>Parailia pellucida</i>	8	6.20–9.30	7.89±1.08	3.10–4.50	3.83±0.46
"	<i>Schilbemystus</i>	29	6.50–8.20	7.43±0.43	2.30–6.10	4.07±0.91
Total Schilbeidae		37				
Clupeidae	<i>Pellonula leonensis</i>	97	3.80–13.30	8.40±1.42	3.00–34.00	7.81±5.40
Total Clupeidae		97				
Mugilidae	<i>Neochelon falcipinnis</i>	31	12.10–7.60	14.67±1.21	17.75–37.86	24.68±4.96
Total Mugilidae		31				
Grand total		462				

Index of preponderance and condition factor of the fish species

Index of Preponderance and condition factor of the fish species are presented in Table 2. *O. niloticus* (72.94%) had the highest significant contribution, followed by *P. leonensis* (9.11%) and *B. longipinnis* (5.54 %). *C. stampflii* had the least index of preponderance (0.00 %). Generally, six fish species showed significant contributions while the remaining six made insignificant contributions to the fishery. A greater number (7 species) of the fish sampled had condition factor (K) less than 1; signifying low body condition or well-being of the fishes while high body condition was recorded in 5 species (Table 2). *Parailia pellucida* had the highest condition factor (13.23), followed by *Pellonula leonensis* (5.81) and *Pelmatolapia mariae* (3.53). The fish species with the least condition factor was *Monodactylus sebae*.

Length- weight relationship (LWR) of the fish species

The growth indices including regression coefficient/growth function (b), regression intercept (a) and the correlation coefficient (r) of 12 fishes are presented in Table 2. Ten out of twelve species showed negative allometric growth ($b < 3$) except *B. longipinnis* that exhibited positive allometric growth ($b > 3$) and *C. stampflii* that LWR was not evaluated since it had only a single specimen. However, the relationship between length and weight for all species were both positively (in 5 species) and negatively (in 6 species) correlated.

Table2: Sample size (N), Index of Preponderance (%IP), condition factor (K) allometric growth pattern (b), scaling constant (a) and regression coefficient (r) of fish species in Qua Iboe River at Onna Bridgehead, Nigeria

Fish species	N	IP (%)	K	b	a	r	R ²	Allometry
<i>B. longipinnis</i>	75	5.54	0.52	3.07	1.49	0.88	0.77	Positive
<i>C. zillii</i>	9	0.26	0.65	2.29	0.87	0.64	0.40	Negative
<i>C. guineensis</i>	20	6.21	0.65	2.13	0.19	0.73	0.53	Negative
<i>P. mariae</i>	3	0.30	3.53	0.04	1.70	0.11	0.01	Negative
<i>O. niloticus</i>	161	72.94	1.05	2.40	0.92	0.87	0.75	Negative
<i>M. sebae</i>	16	1.95	0.15	2.84	1.36	0.89	0.29	Negative
<i>C. stampflii</i>	1	0.00	NA	0	0.00	0	0	0
<i>C. nigrodigitatus</i>	12	0.29	0.96	2.27	1.04	0.89	0.79	Negative
<i>P. pellucida</i>	8	0.03	13.23	0.20	-0.08	0.23	0.05	Negative
<i>S. mystus</i>	29	0.42	1.28	2.66	1.37	0.68	0.46	Negative
<i>P. leonensis</i>	97	9.11	5.81	1.54	0.29	0.58	0.33	Negative
<i>N. falcipinnis</i>	31	2.94	0.68	2.14	0.85	0.95	0.85	Negative

Discussion

A total of 12 fish species, 10 genera and 8 families consisting of 462 individuals were encountered in Qua Iboe River, Onna Bridgehead. Functional indicators measure the services or functions provided by the ecosystem, while structural indicators measure what lives in an ecosystem (Williamson *et al.*, 2008); and monitoring changes in community composition and any shift within an eco-region may be a good indicator (Ekpo *et al.*, 2012a). The ichthyofaunal species composition in this work is made up both brackishwater and euryhaline species as evident in families such as Alestidae, Cyclopsettidae, Mugilidae, Monodactylidae; and freshwater species as seen in the families of Schilbeidae and Cichlidae obtained in the present study. Similar findings have been reported by several Nigerian authors such as Offemet *et al.*, (2009); Onuoha *et al.*, (2010); Ekpo *et al.*, (2012b); Ekpo and Udoh (2013).

Fish yield is studied using weight as a measure of size. LWR and K are important fishery management tools (Bagenal and Tesch, 1978). LWR relationship provides information on the relative wellbeing of fish population, determines whether somatic growth is isometric or allometric (LeCren, 1951). In this study, b showed 83.4% negative allometry and 16.6% positive allometry. These were within the expected range of 2-4 that was recommended (Bagenal and Tesch, 1978) as adequate for tropical fish except for *C. stampflii*(0) *C. mariae* (0.04) and *P. pellucida* (0.20). It is necessary to know that growth is isometric when b=3, values greater or less than 3 are allometric. The negative allometry (b<3) is an indication that the fish are lighter than their body weights while positive allometry (b>3) indicates that fish are heavier than their lengths. However, isometric growth when b=3 indicates the fish is neither too heavy nor light for their sizes (Lawson *et al.*, 2013). According to Riedel *et al.*, (2007), a negative allometric growth implies that the fish is becoming tinnier as it increases in weight; hence, the fishes become slender and vice versa for a positive allometric growth where the fish larger as it increases in weight. An isometric LWR on the other hand implies that the weights of the fishes increase at approximately the same rate as the length (Olufeagba *et al.*, 2016).

In the present study, the values of b for the LWR were found to show negative allometry for 10 out of 12 fish species. This indicates that the fish grows at different rates from the rest of the body. The allometric negative growth pattern has been observed in several fish species across several river ecosystems in Nigeria including *C. nigrodigitatus* from Cross River (Ndibukke and Amachree, 2019); *N. falcipinnis* for Sombriero River (Dienye and Olopade, 2020); *C. mariae* from Anambra River (Atama *et al.*, 2013); *P. leonensis* from Anambra River (Ezenwaji and Offiah, 2003); *C. guineensis* from New Calabar River (Olopade *et al.*, 2018); *S. mystus* from Kubanni reservoir (Ogbeet *et al.*, 2019).

Growth pattern and growth rates are highly species-specific and each species has growth characteristic of its own with respect to factors such as optimum temperature, adequate food and seasonal changes (Gupta and Gupta 2006). Differences in parameters “b” of LWR may be attributed to several factors which include season, habitat, gonad maturity, sex, diet, stomach fullness, health, preservation techniques and annual differences in environmental conditions (Bagenal and Tesch, 1978, Lawson *et al.*, 2013). In addition, growth increment, differences in age, stage of maturity, food, temperature, salinity and seasonality can also affect the values of b for some species. Age, maturity and sex (Hossain, 2010); feeding, reproduction and fishing activities (Bayhan *et al.*, 2008); environmental

changes, individual metabolism, sexual maturity and age (Franco-Lopez *et al.*, 2010) are also some factors that affect values of *b*. It is also inferred that higher *b* values imply relatively productive environmental conditions (Gopakumaret *al.*, 1991).

Condition factor compares the wellbeing of fish with the hypothesis that heavier fish of a given length are in better physiological condition than the less robust in relation to its welfare (LeCren, 1951; Bagenal and Tesch, 1978). From the condition factor for the twelve fish species collected, it was observed that about 25% (3 out of 12 species) of the fish species had their *K* values below the range 2.9-4.8 recommended as suitable for matured freshwater fish. According to Lagler (1956), it has been found that the value of *K* is not constant for individuals, species or populations but is subject to wide variations for fish of average natural condition; the *K*-factor should be equal to 1, while <1 and >1 indicate below and above average conditions respectively. It may vary from species to species and change according to morphology, sex, age, and reproductive state associated with gonadic maturity stages variations (Bagenal and Tesch (1978).

Cichlidae was the most abundant family while *Oreochromis niloticus* was the most abundant species. The species making insignificant contribution were more in number than those that contributed significantly. This same trend was observed in the condition factor of the fishes as those with low condition were more than those with high well-being. Based on the relationship between fish length and weight, almost all the species showed negative allometric growth pattern except for *Brycinus longipinnis* that revealed positive allometry.

This study has provided baseline information on the fish composition, abundance, size, length-weight and condition factor on fish species which are relevant for stock assessment and sustainable fishery management in the river. The negative allometric growth pattern recorded in almost all the species during the study could be attributed to intense fishing pressure and therefore there is a need for government to introduce fishery management techniques to regulate the fishing activities in the river for sustainability of this fishery. The information further provides useful tool for sampling programs, to estimate growth rates and other components of fisheries management. This piece of work has serve as benchmark information for further researches in Onna River, Nigeria.

References

- Adaka, G.S., Nlewadim, A.A. and Udoh, J.P. (2016). Diversity and distribution of freshwater fishes in Oguta Lake9 Southeast Nigeria. *Advances in Life Science and Technology*, 25-32.
- Atama, C.I., Okeke, O.C., Ekeh, F.N., Ezenwaji, N.E., Onah, I.E., Ivoke, N., Onoja, U.S. and Eyo, J.E. (2013). Length- weight relationship and condition factor of six cichlid (Cichlidae: Perciformes) species of Anambra River, Nigeria. *Journal of Fisheries and Aquaculture*, 4(2): 82-86.
- Bagenal, T.B. and Tesch, F.W. (1978). Age and growth. In: Bagenal, T. (ed.). *Methods for assessment of fish production in freshwaters*. 3rd edn. IBP Handbook No. 3, Blackwell Scientific Publications: Oxford, UK, pp: 101-136.
- Bolarinwa, J.B. and Popoola, Q. (2013). Length-weight relationships of some economic fishes of Ibeshe Waterside, Lagos Lagoon, Nigeria. *J. Aquac. Res. Development*, 203 doi:10.4172/2155-9546.1000203
- Bolarinwa, J.B., Fasakin, E.A. and Fagbenro, A.O. (2015). Species composition and diversity of the coastal waters of Ondo State, Nigeria. *International Journal of Research in Agriculture and Forestry*, 2(3): 51-58.
- Bayhan, B., Sever, T.M. and Taskavak, E. (2008). Length-weight relationships of seven flatfishes (Pisces: Pleuronectiformes) from Aegean Sea. *Turkish Journal of Fisheries and Aquatic Science*, 8: 377-379.
- Dienye, H.E. and Olopade, O.A. (2020). Growth pattern of three species of Mulletts (Pisces: Mugilidae) in Sombreior River, Rivers State, Niger Delta, Nigeria. *Aceh Journal of Animal Science*, 5(2): 68-72.
- Ekpo, I.E. and Udoh, J.P. (2013). Species richness and diversity of ichthyofaunal communities of the lower Cross River floodplain, Nigeria. *International Research Journal of Environment Sciences*, 2(7): 5-14.
- Ekpo, I.E., Chude, L.A. and Onuoha, G.C. (2012a). The use of multivariate analysis for characterization and classification of Ikpa River, Nigeria. *Elixir Agriculture*, 49: 9799-9807.
- Ekpo, I.E., Udo, M.T. and Usip, P.L. (2012b). Seasonality and size variation of fish species in Nwaniba, Ikpa River southeast Nigeria. *Elixir Aquaculture*, 51(2012): 11043-11050.
- Ezenwaji, H.M.G. and Offiah, F.N. (2003). The biology of *Pellonulaleonensis* Boulenger, 1916 (Osteichthyes: Clupeidae) in Anambra River, Nigeria. *Journal of Biological Research and Biotechnology*, 1(2): 33-50.
- Food and Agriculture Organization (FAO) (1990). Field guide to the commercial marine resources of the Gulf of Guinea. FAO species identification sheets for fishery purposes, Rome. 268pp.

- FAO (2018). The state of world fisheries and aquaculture 2018 - meeting the sustainable development goals. Rome. Licence: CC BY-NC-SA 3.0 IGO.
- Franco-Lopez, J., Sanchez, C.B., Escorcía, H.B., Abarca-Arena, L.G., Ferreira T.C. and Vazquez-Lopez, H. (2010). Biological and ecological aspects regarding *Cynoscionnothus*(Holbrook, 1855) (Perciforms: Sciaenidae). *Research Journal of Fisheries and Hydrobiology*, (2): 66-75.
- Gayanilo, F.C. Jr. and Pauly, D. (1997). FAO–ICLARM Stock assessment tools reference manual. *FAO Comp. Information Serv. (Fish)*, FAO No. 8. Rome.
- Gopakumar, G.N., Gopalakrishna, P. and Omana, T.A. (1991). The fishery characteristics and biology of mackerel at Vizhinjam. *Journal of Marine Biological Association India*, 33: 07-114.
- Gupta, S.K. and Gupta, P.C. (2006). General and applied ichthyology. S. Chand and Co. Ltd: New Delhi, India.
- Hossain, M.Y. (2010). Morphometric relationships of length-weight and length-length of four cyprinid small indigenous fish species from the Padma River (NW Bangladesh). *Turkish Journal of Fisheries and Aquatic Science*, 10: 131-134.
- Idodo-Umeh, G. (2005). Freshwater fishes of Nigeria. Idodo-Umeh Publishers, Nigeria. 229pp.
- King, M. (1995). Fisheries Biology: assessment and management. Fishing News Books: Oxford, UK.
- Lagler, K.F. (1956). Freshwater Fishery Biology. W.C. Brown Company: Dubuque, IA., USA., pp: 159-166.
- Lawson, E.O., Akinde-Peters, O. and George, A.O. (2013). Aspects of the biology of African Moony, *Monodactylus sebae* from Badagry Creek, Lagos, Nigeria. *Advances in Life Science and Technology*, 12: 5-12.
- Le Cren, E.D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *Journal of Animal Ecology*, 20: 201-219.
- Ndibukke, M.E. and Amachree, D. (2019). Length-weight relationship and condition factor of *Chrysichthys nigrodigitatus* (Lacepède, 1803) from Itu, Akwa Ibom State, Nigeria. *Global Scientific Journals*, 7(7): 902-912.
- Offem, B.O., Samsons, Y.A. and Omoniyi, I.T. (2009). Length-weight relationship, condition factor and sex ratio of forty-six important fishes in a tropical flood river. *Research Journal of Fisheries and Hydrobiology*, 4(2): 65-72.
- Ogbe, E.O., Dambo, A. and Bamaïyi, C. (2019). Length-weight relationships and growth pattern of some selected fish species in Kubanni reservoir, Kadauna State, Nigeria. *International Journal of Fisheries and Aquatic Studies*, 7(5): 190-193.
- Olaosebikan, B.D. and Raji, A.A. (2004). Field guide to Nigerian freshwater fishes, 2nd Edition.
- Olopade, O.A., Dienye, H.E. and Eyekpegba, A. (2018). Length frequency distribution, length-weight relationship and condition factor of cichlid fishes (Teleostei: Cichlidae) from the New Calabar River, Nigeria. *Iranian Journal of Ichthyology*, 5(1): 74-80.
- Olufeagba, S.O., Okomoda, V.T. and Shaibu, G. (2016). Embryogenesis and early growth of pure strains and hybrids between *Clarias gariepinus* (Burchell, 1822) and *Heterobranchus longifilis*(Valenciennes, 1840). *North American Journal of Aquaculture*, 78(4):346-355.
- Omoniyi, I., Agbon, A.O. and Sodunke, S.A. (2002). Effect of lethal and sublethal concentrations of tobacco (*Nicotiana tobaccum*) leaf dust extract on weight and hematological changes in *Clarias gariepinus* (Burchell). *J. Applied Sci. Environ. Mgt.*, 6(2): 37-41.
- Onuoha, G.C., Ekpo, I.E., Chude, L.A. and Isangedighi, I.A. (2010). Composite preliminary ichthyofaunal survey of Ntak Inyang Stream, Ikpa River, Nigeria. *Nigerian Journal of Agriculture, Food and Environment*, 6(1&2):82-89.
- Riedel, R., Caskey, L.M. and Hurlbert, S.H. (2007). Length weight relations and growth rates of dominant fishes of the Salton Sea: implications for predation by fish-eating birds. *Lake and Reservoir Management*, 23: 528-535.
- Stavrescu-Bedivan, M., Scăteanu, G.V., Madjar, R.M., Matei, P.B. and Tobă, G.F. (2015). Comparative study of length-weight relationship, size structure and Fulton's condition factor for Prussian carp from different Romanian aquatic ecosystems. *Scientific Journal*, 4(2): 132-139.
- Williamson, C.E., Dodds, W., Kratz, T.K. and Palmer, M.A. (2008). Lakes and streams as sentinels of environmental change in terrestrial and atmospheric processes. *Front Ecology and Environment*, 6(5): 247-254.

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Length-Weight Relationship of *Oreochromis niloticus* from Epe Lagoon, Lagos State, Nigeria

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Abstract

The study of length-weight relationship and condition factor of one hundred and twenty (120) *Oreochromis niloticus* from Epe lagoon, Lagos State, Nigeria were studied for a period of four months between June to September 2019. The results obtained from the study revealed that the values of mean K were 1.926 and 1.973 for female and male respectively. While, The 'a' values were 0.0191 and 0.0224 for female and male respectively while the 'b' value obtained were are 3.0018 and 2.9545 for female and male respectively. There was no significant difference between the "K" value of male and female *O. niloticus* in the lagoon. The result also revealed that *O. niloticus* in Epe Lagoon are healthy. The lagoon should be monitored in order to preserve the fishery resources in this environment.

Introduction

Nile tilapia, *Oreochromis niloticus* is one of the most known members of the tropical and subtropical freshwater fishes. It is recommended by the FAO as a culture fish species because of its importance in aquaculture and its capability in contributing to the increased production of animal protein in the world (Bagenal and Tesch 1978). It has been reported by Edwards (2000) that out of more than 100 species of tilapia, only few species have potential for aquaculture, of which, two species belonging to genus *Tilapia* (*T. zillii* and *T. rendalli*) and four species belonging to genus *Oreochromis* (*O. niloticus*, *O. aureus*, *O. mossambicus* and *O. andersonii*).

The length-weight relationship (LWR) is an important factor in the biological study of fishes and their stock assessments (Haimovici and Velasco, 2000). It is also used to determine possible differences between separate unit stocks of the same species (King, 2007). The LWR is helpful for estimating the weight of a fish of a given length and also in studies of gonad development, rate of feeding, metamorphosis, maturity and condition (Thomas et al., 2003). LWR of fishes can be used as an estimation of the average weight of the fish of a given length group by establishing a mathematical relation between the two (Teixeira de Mello et al., 2006).

The condition factor often referred to as 'K' factor provides information on well being of a fish and is usually influenced by age of fish, sex, season, maturity stages, etc (Anyanwu, et al. 2007). Fish specimens of a given length exhibiting higher weight are said to be in a better condition. The condition factors of gravid female are usually higher but decreases after the eggs are shed. Fulton proposed the use of a mathematical formula for quantifying the condition of fish as $K = 100WL^{-1}$. This study is aimed at establishing and accessing the length-weight relationship of *Oreochromis niloticus* from Epe lagoon, Lagos State, Nigeria.

Materials and Methods

The total number of one hundred and twenty *Oreochromis niloticus* from Epe lagoon were procured monthly from fresh fish sellers at chief market, Epe, Lagos State, Nigeria, from June to September, 2019. The samples were transported in a plastic bucket filled with crushed ice to Federal College of Fisheries and Marine Technology research laboratory. The total length (TL) and standard length (SL) were measured for each fish using a measuring board and the corresponding total weight (TW) was measured using a digital scale to nearest 0.1cm and 0.01g respectively. The sex of the fish was determined through the physical appearance of their genital papilla, plate 1 as reported by Muller-Beleck and Horstgen-Schwark, (1995).



Plate 1: male and female sexes of *O. niloticus*

The LWR was estimated using the equation $W = aL^b$, where W = body weight, L = total length in centimeter while 'a' and 'b' are regression constant and regression coefficient respectively (Ricker, 1973). The values of constant 'a' and 'b' were estimated from transformed values of length and weight, ie $\log w = \log a + b \log L$. the analysis was carried out using Microsoft Excel. The condition factor was calculated using formula by Pauly (1983).

Results and Discussion

The LWR and condition factor of *O. niloticus* (male and female) from Epe lagoon sampled between June to September are presented in Table 1. The mean K values are 1.926 and for female and male respectively. The 'a' values are 0.0191 and 0.0224 for female and male respectively while the 'b' value are 3.0018 and 2.9545 for female and male respectively. Growth is said to be positive allometric when the weight of an organism increased more than the length ($b > 3$) and negative allometric growth when the length of an organism increased more than the weight ($b < 3$). Enin, (1994) stated that when $b=3$, the growth is said to be isometric. All the condition factor ("K") values were found to be greater than 1. There was no significant difference between the "K" value of male and female *O. niloticus* ($p < 0.05$). The "k" values obtained in this study are less than the values (2.9-4.8) documented by Bagenal and Tesch (1978) for matured *O. niloticus*. A condition factor greater or equal to one is good, indicating a good level of feeding, and proper environmental condition by Ujjania et al. (2012). The result of the physico-chemical parameters of Epe lagoon is shown in table 2.

Table 1: length-weight relationship and condition factor of male and female *O. niloticus*.

Parameters	Regression constant ("a")	Regression coefficient ("b")	Mean condition factor (K)	K Maximum	K minimum	R ²
Female	0.0191	3.0018	1.926	2.594	1.666	0.9835
Male	0.0224	2.9545	1.973	2.924	1.418	0.9727

The regression graph of Combine sex, Female and Male LWR of *O. niloticus* from Epe Lagoon is presented in Fig. 1, 2, and 3 respectively.

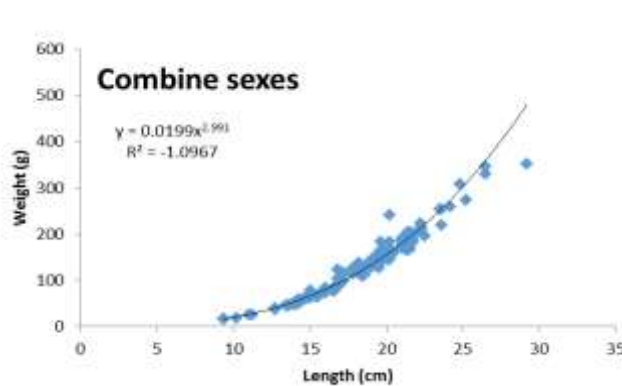


Fig 1: LWR of combine sex of *O. niloticus*

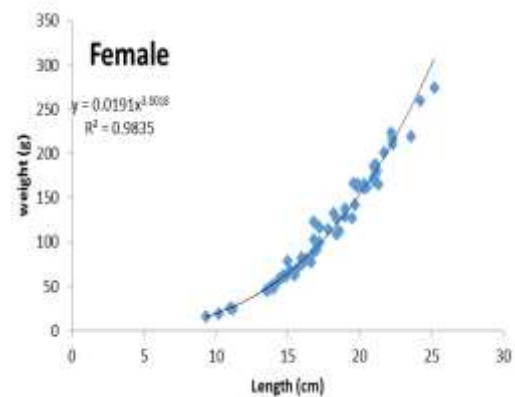


Fig 2: LWR of female *O. niloticus*

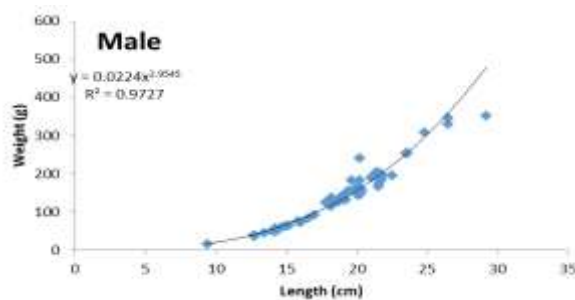


Fig 3 : LWR of male *O. niloticus*

Conclusion and Recommendation

This study revealed that *O. niloticus* in Epe Lagoon are healthy. The water physico-chemical parameter also shows that the lagoon was not polluted at the time this study was carried out. The lagoon should to monitored in order to preserve our fishery resources in Epe lagoon.

References

- Anyanwu, P. E., Okoro, C. B., Anyanwu, A. O., Matanmi, M. A., Ebonwu, B. I., Ayobu-Cookey, I. K., Hamzat, M. B., Ihimekpen, F. And Afolabi, S. E. (2007) Lenght – Weight Relationship, Condition Factor and Sex Ratio of African Mudcatfish (*Clarias gariepinus*) Reared in Indoor Water Recirculation System Tanks. *Research journal of Biological sciences*. 2 (7): 780 – 783.
- Bagenal TB, Tesch FW (1978). Age and growth. In Bagenal, T.B. (ed);Methods of assessment of fish production in fresh waters. Oxford Blackwell Scientific Publication, pp. 101-136.
- Edwards P. C., Lin, K. and Yakupitiyage, A. (2000). Semi-intensive pond aquaculture. In: Beveridge M. C. M., McAndrew B. J. (Eds). Tilapias: Biology and Exploitation. Dordrecht/ Boston/London, Kluwer Academic Publishers, *Fish and Fisheries Series* 25: 377-403.
- Enin U (1994). Length-weight parameters and condition factor of two West African Prawns. *Review Hydrobiol. Trop.* 27:121-127.
- Haimovici M, Velasco G (2000). Length-weight relationship of marine fishes from Southern Brazil. *NAGA: ICLARM Q*, 23: 19-23.
- King, M. (2007): Fisheries Biology Assessment and Management 2nd edition, Blackwell Scientific Publications, Oxford Pp.189-192

- Müller-Belecke, A., Hörstgen-Schwark, G., 1995. Sex determination in tilapia (*Oreochromis niloticus*) sex ratios in homozygous gynogenetic progeny and their offspring. *Aquaculture* 137, 57–65.
- Pauly D (1993). Fishbyte section editorial. *Naga. ICLARM Q.* 16: 26.
- Ricker, W. E. (1973) Linear regressions in fisheries research. *J. Fish. Res. Board Can.*, 30: 23 – 25.
- Tebiera de Mello RS (2006). The condition factor of fish from two river basins in Sao Paulo, Brazil. *Acta Scienta Maringa*, 24 (3): 14-18.
- Thomas J, Venu S, Kurub BM (2003). Length- weight relationship of some deep-sea fish inhabiting the continental slope beyond 250m depth along the west coast of India. *NAGA, ICLARM Quarterly*, 26(2):17 - 21.
- Ujjania N.C., Kohli M.P.S. and Sharma L.L. (2012). Length-weight relationship and condition factors of Indian major carps (*C. catla*, *L. rohita* and *C. mrigala*) in Mahi Bajaj Sagar, India. *Research Journal of Biology*, 2 (1), 30-36.

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Comparative Fecundity And Stages Of Egg Development Of *Atya gabonensis* (Giebel, 1875) (Crustacea: Atyidae) From Three Different Locations In Nigeria

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Abstract

Comparative studies of fecundity and stages of egg development of *Atya gabonensis* in River Benue, Makurdi, River Niger, Jebba and the Confluence of the two rivers in Ganaja was done from January 2016 to December, 2017. A total of 300 berried females were collected with the aid of fishermen and transported in ice box to the laboratory for further studies. Species identification, sexes of the specimen, morphological measurements and fecundity were carried out using standard methods. The results obtained indicated that the number of eggs varied from 550 – 36,673 in Jebba, 300 – 24,532 in Ganja and 4,300 – 8,600 in Makudi. Positive correlation was observed between fecundity and morphometric parameters investigated in all the locations. All the ovigerous females in Makurdi, 14% in Ganaja and 17% in Jebba were in stage 1. Ganaja and Jebba had 39% and 35% respectively in stage 2. Stage 3 was occupied by 26% from Ganaja and 12% from jebba. Stage 4 had 10% from Ganaja and 17% from Jebba while stage 5 had 11% from Ganaja and 19% from Jebba. It was concluded that *A. gabonensis* is fecund and could make an excellent candidate for aquaculture. Though Makurdi, Ganaja and Jebba are recommended for collection of its broodstock, it is suspected that Makurdi may not be a spawning ground for this species but Ganaja and Jebba are good breeding sites.

Keywords: Fecundity, stages of egg development, Makurdi, Ganaja and Jebba

Introduction

Prawns are important fisheries resources with substantial economic benefits in the supply of quality protein, generation of employment and foreign exchange earnings (FAO, 2008). *Atya gabonensis* is one of the prawn species which has been reported in America and Africa, including Nigeria (Okayi *et al.*, 2010). Prawn production in Nigeria is mostly wild-caught and in small quantity (about 12,000 tonnes annually) (Zabby *et al.*, 2010). Prawn culture in Nigeria is undeveloped due to lack of sufficient information on their reproductive biology. Some studies have been done on the biology of *A. Gabonensis* in Nigeria. These include Powell (1982), Anetekhai (1990), Solomon *et al.* (1999), Obande (2006) Obande and Kusemiju (2006), Nwosu (2009), and Okayi *et al.* (2010). But not much has been done to ascertain its reproductive capacity. The knowledge of reproductive capacity of this species of prawn abundant in Nigerian inland waters would contribute to its successful culture in Nigeria. Hence, this study is designed to provide necessary information on the comparative fecundity and stages of egg development of *A. gabonensis* in River Benue, Makurdi, River Niger, Jebba and the Confluence of the two rivers, Ganaja

Materials and Methods

Study Areas

The sample collection sites were Makurdi, Jebba and Ganaja (Figure 1). Makurdi is located on latitude 7° 55' and 7° 56' North of equator and longitude 8° 20' and 8° 40' East of the Greenwich meridian. Jebba is located on latitude 9° 35' and 9° 50' N and longitude 9° 30' and 5° 00' E. Ganajais located between latitude 7° 45' N and 8° 12' N and longitude 6° 39' E and longitude 7° 00' E.

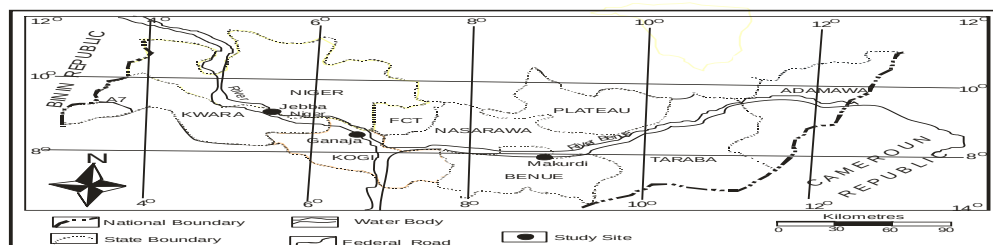


Figure 1: Map Showing Sample Collection Site at Makurdi, Jebba and Ganaja (Modified from Obaje, 2009)

Prawn Collection and Studies

Prawns were collected with the aid of fishermen and transported in iced box to the laboratory for further studies. Identification to species level was by keys of Powell (1982). The sexes were determined with the aid of specific morphological features that were peculiar to male and females of the prawns, such as appendix masculina, reproductive chamber and nubs on the first abdominal segment as demonstrated by Anetekhai (1990). Morphological measurements were done according to a model of Adete *et al*, (2013). Total body weight (g) was taken using a top loading electronic Metler balance (Model 59174) to the nearest gram. Fecundity was estimated by the gravimetric method of Fernandez *et al*. (1998). Stages of egg development were characterized base on the colour of egg mass according to Anetekhai (1990).

Results

Mean Fecundity of *Atyagabonensis* From Ganaja, Makurdi and Jebba

Table 1 presents the mean fecundity of *Atya gabonensis* from Ganaja, Makurdi and Jebba. One hundred (100) specimens were sampled from each location for fecundity study. There was significant difference ($P < 0.05$) in the fecundity of *A. gabonensis* from the 3 locations. Specimens from Jebba had the highest mean fecundity ($11,937 \pm 902$) followed by the specimens from Ganaja (mean fecundity = $9,575 \pm 515$) while the lowest fecundity ($6,450 \pm 2,150$) was recorded for Makurdi. The number of eggs varied from 550 – 3,6673 in Jebba from 300 – 24,532 in Ganja and 4,300 – 8,600 in Makurdi.

Table 1: Mean Fecundity of *A. gabonensis* from Ganaja, Makurdi and Jebba (January 2016 to December 2017)

Station	Mean	Minimum	Maximum	N
Lokoja	$9,575 \pm 515^b$	300	24,532	100
Makurdi	$6,450 \pm 2150^c$	4,300	8,600	100
Jebba	$11,937 \pm 902^a$	550	36,673	100

Numbers in each cell are means $\pm$ standard error. Mean in the same column with different superscript differ significantly ($P < 0.05$).

Correlation matrix of morphometric parameters and fecundity

In Ganaja, all the features correlated positively with fecundity (Tabel 2). The most correlated feature with fecundity was total length ($r = 0.87$). In Jebba, positive correlation was observed too between fecundity and all the features recorded (Tabel 3). But the most correlated feature with fecundity was body weight ($r = 0.86$) while the least correlated features were carapace diameter and carapace length ($r = 0.59$). Table 4 shows correlation matrix of morphometric parameters and fecundity of *A. gabonensis* from Makurdi. Positive correlation was observed between fecundity and other features measured except with CD. Stronger correlation was observed between Fecundity and total length ($r = 0.64$).

Table 2: Correlation Matrix of Morphometric Parameters and Fecundity of *A. gabonensis* from Ganaja (January 2016 to December 2017) (n=100)

	W	TL	CL	CD	AL
TL	0.63				
CL	0.58	0.88			
CD	0.56	0.71	0.80		
AL	0.56	0.87	0.99	0.82	
Fecundity	0.65	0.87	0.78	0.64	0.78

Keys: W=Weight; TL = Total length; CL = Carapace length; CD = Carapace diameter; AL = Abdomen length.

Table 3: Correlation Matrix of Morphometric Parameters and Fecundity of *A. gabonensis* from Jebba (January 2016 to December 2017) (n=100)

	W	TL	CL	CD	AL
TL	0.80				
CL	0.68	0.82			
CD	0.67	0.75	0.83		
AL	0.72	0.89	0.92	0.86	
Fecundity	0.86	0.76	0.59	0.59	0.68

Keys: W=Weight; TL = Total length; CL = Carapace length; CD = Carapace diameter; AL = Abdomen length

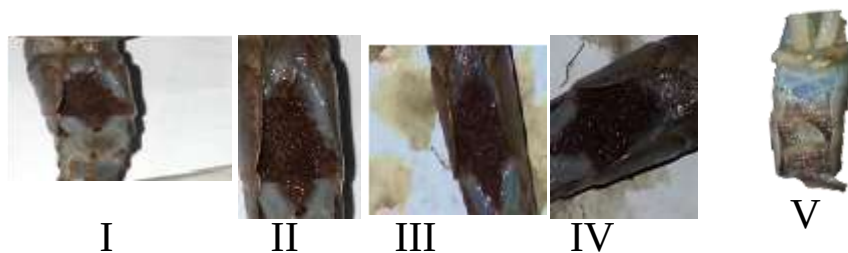
Table 4: Correlation Matrix of Morphometric Parameters and Fecundity of *A. gabonensis* From Makurdi (January 2016 to December 2017) (n=318)

	W	TL	CL	CD	AL
TL	0.29				
CL	0.26	0.81			
CD	0.03	-0.15	-0.15		
AL	0.23	0.48	0.54	-0.11	
Fecundity	0.42	0.64	0.57	-0.00	0.14

Keys: W=Weight; TL = Total length; CL = Carapace length; CD = Carapace diameter; AL = Abdomen length.

Stages of egg development of *A. gabonensis* from Ganaja, Makurdi and Jebba

Figure 2 shows the frequency distribution of stages of egg development of *Atya gabonensis* from Ganaja, Makurdi and Jebba. The bar chart shows percentage of ovigerous females versus stages of egg development. All the ovigerous females found in Makurdi, 14% of the ovigerous females in Ganaja and 17% in Jebba were in stage 1. Most ovigerous females in both Ganaja and Jebba (39% and 35% respectively) were in stage 2. Ganaja had 26% and Jebba had 12% of the ovigerous females in stage 3. Stage 4 had 10% from Ganaja and 17% from Jebba while stage 5 had 11% from Ganaja and 19% from Jebba.

**Plate 1: Different Stages of Embryonic Development Based on Egg Colour of *A. gabonensis***

Egg colour of *A. gabonensis* during embryonic development

Eggs were categorized by colour of into Five (5) stages. At stage 1, eggs were newly spawned, immature with uniform yolk and no eye pigments visible. They appeared Light orange. In stages II (dark orange), III (light brown) and IV (dark brown), the colour change indicates that development is in progress. Eye pigments are barely visible. Eggs in Stage V are gray in colour, fully developed and two eye spots are visible, ready for hatching.

Discussion

Fecundity of *A. gabonensis*

The results of fecundity in this study is higher than that of Obande et al. (2009) on the same species in the Lower River Benue. The differences may be related to environmental aspects, genetic variations of populations and predation on eggs. However, fecundity in this study is far lower than what was observed on prawns of the genus *macrobrachium*. For example, New and Singholka (1982) reported 100,000 - 700,000 eggs in *M. rosenbergii*. This is an indication that prawns of *macrobrachium* genus are more fecund than *A. gabonensis*. This was confirmed by (Anetekhai 1990). The Fecundity/total length relationships shows an increase in number of eggs with increasing female size; a similar situation was also observed by Albertoni et al. (2002) in *M. acanthurus*, Hart et al. (2003) in *M. felicinum* and Deekae and Abowei (2010) in *M. macrobrachion*. The increase of fecundity with body size seems to be a rule that is applicable to many crustaceans (Udo and Ekpe, 1991).

Conclusion

All the stages of egg development were represented in the samples. However, only the first stage of egg development was observed at Makurdi. The five stages were observed at Ganaja and Jebba. It is suspected that River Benue may not be a spawning ground for this species and they probably migrate to the Confluence and River Niger to spawn.

References

- Albertoni, E., Palma-Silva, C. and Esteves, F. (2002). Fecundity of *Macrobrachium acanthurus* Eiegmann, 1836 (Decapoda: Palaemonidae) in a Tropical Coastal Lagoon Subjected to Human Impacts (Mace, Brazil). *Acta Limnologica Braziliensia*, 14(1): 71-80.
- Anetekhai, M.A. (1990). Sexual Dimorphism and Egg Production in Africa River Prawn *Macrobrachium vollenhovenii* from Asejire Lake, Oyo State, Nigeria. *Nigerian Journal of Science*, 24: 147-151.
- Adite, A., Abou, Y., Sossoukpe, E., Gbaguidi, M.H.A.G. and Fiogbé, E.D. (2013). Meristic and Morphological Characterization of the Freshwater Prawn, *Macrobrachium macrobrachion* (Herklots, 1851) from the Mono River-Coastal Lagoon System, Southern Benin (West Africa): Implications for Species Conservation. *International Journal of Biodiversity and Conservation*, 5(11): 704-714. doi: 10.
- Deekae, S.N and Abowei, J.F.N. (2010). *Macrobrachium macrobrachion* (Herklots, 1851) Length-Weight Relationship and Fulton's Condition Factor in Luubara creek, Ogoni Land, Niger Delta, Nigeria. *International Journal of Animal and Veterinary Advances* 2(4): 155-162.
- Fernandez-Palacios, H.Q., Robaina, M.L. and Valencia, A. (1998). Combined Effect of Dietary α -tocopherol and n-3 HUFA on Eggs Equality of Gilthead Sea Bream Brood Stock (*Sparus aurata*). *Aquaculture*, 161:475-476.
- FAO (2008). Global Study of Shrimp Fisheries. FAO fisheries technical paper, 475pp
- Hart, A.I., Ansa E. J. and Sekibo, I. (2003). Sex Ratio, Sexual Dimorphism and Fecundity in Pond Reared Niger River Prawn, *Macrobrachium felicinum* (Ilolthuis, 1949). *The Zoologist*, 2(1): 56-61.
- New, M. B. and Singholka, S. (1982). Freshwater prawn farming: Manual for the culture of *Macrobrachium rosenbergii*. FAO- Fisheries Technical Paper No., 225, 1982, 116.
- Nwosu, F. M. (2009). Aspects of the biology of the Gabon Shrimp *Atyagabonensis*. *Journal of Fisheries International*, 4(4):58-61.
- Obaje, N. G. (2009). Geology and Mineral Resources of Nigeria, London: Springer Dordrecht Heidelberg, Pp5-14.
- Obande, R. A. (2006). The biology of *Atyagabonensis* from Lower River Benue. Ph.D. Thesis, University of Lagos, Lagos. 70pp.
- Obande, R. A. and Kusemiju, K. (2006). Food and feeding habit of *Atyagabonensi* from Lower River Benue in Northern Nigeria. *West African Journal of Applied Ecology*, 13: 19-18.
- Okayi, R. G., Ataguba, G. A. and Nyishagba, O. (2010). Biology of two freshwater prawns (*Palaemonetes africanus* and *Demoscaris bislineata*) from the Mu River, Makurdi-Benue State. *Journal of Animal and Plant Science*, 5(3): 544-549.
- Powell, C. B. (1982). Fresh and Brackish water prawns of economic importance in Niger Delta. In proceedings of 2nd Conference of Fisheries Society of Nigeria, Calabar, 22-24 Jan 1982, pp 254-285.
- Solomon, S.G., Obande, R.A. and Imgbian, T.D. (1999). Aspects of Biology and Racial Characteristics of Gabon Shrimp, *Atyagabonensis* in River Benue. *Journal of Agriculture, Science and Technology* 9-11: (1 and 2).
- Udo, P. J. and Ekpe, E. D. (1991). Fecundity in the African river prawn *Macrobrachium vollenhovenii* (HERKLOTS, 1857) from natural habitats. *Journal of Aquaculture in the Tropics*, 6: 173-177.

Zabbey, N., Erundu, E. S. and Hart, A. I. (2010). Nigeria and the prospect of shrimp farming: critical issues. *Livestock Research for Rural Development*. Volume **22**, Article #198. Retrieved January 17, 2016, from <http://www.lrrd.org/lrrd22/11/zabb22198.htm>

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Aspects of Reproductive Biology of Freshwater Prawn *Atya gabonensis* (Giebel, 1875) (Crustacea: Atyidae) From River Niger, Jebba, Kwara State, Nigeria

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Abstract

Aspects of reproductive biology of *Atya gabonensis* was investigated in River Niger, Jebba from January 2016 to December 2017. About 3,312 specimens were collected with the aid of fishermen and transported in icebox to the laboratory for further studies. Species identification, sexes of the specimen, morphological measurements and fecundity were carried out using standard methods. The egg diameters were measured to the nearest millimetre using a calibrated eye piece of a binocular microscope. The results obtained revealed that the highest percentage of moulted specimens was observed in March (45.53% and 40.77% in 2016 and 2017 respectively) while the lowest percentage was in December (0.76% in 2016 and 1.24% in 2017). Sex ratio was 1:4.12 (F: M) and 1:2.29 (F:M) in 2016 and 2017 respectively. Mean fecundity was $11,937 \pm 902$ and mean egg size was 0.49 ± 0.009 . Mean gonad weight was 0.03 ± 0.003 in male and 0.07 ± 0.003 in female. Gonadosomatic Index was 0.30 ± 0.02 in male and 0.35 ± 0.01 in female *Atya gabonensis* suspected to breed in freshwater and could make an excellent candidate for aquaculture. Jebba is recommended for collection of *A. gabonensis* broodstock and seed at the onset of rainy season.

Key words: Freshwater, Prawn, Reproductive biology, River Niger, Jebba

Introduction

Prawns are valued food organisms and have been considered one of the most important internationally traded fishery products, which generate substantial economic benefits, especially for many developing countries (FAO, 2008). Nigeria is among the tropical countries endowed with rich prawn resources (Zabby *et al.*, 2010) but has not maximized her potential at production capacity of 12,000 MT annually, mainly from the wild. Prawn farming is still at embryonic stage due to challenges such as lack of broodstock and post larvae for stocking grow out ponds. Studies on the ecology, biology, behaviour and distribution of indigenous Nigerian prawn species have been carried out by various researchers, to provide the scientific lead way for prawn culture, Powell (1982), Anetekhai (1986), Solomon *et al.* (1999), (Abowei *et al.* 2006), Obande (2006), Obande and Kusemiju (2006), Nwosu (2009), and Okayi *et al.* (2010). Despite this, little has been done on the reproductive biology and suitability for culture in captivity of freshwater prawn, *Atya gabonensis*, which dominates the Nigerian inland waters. This study aims to investigate aspects of reproductive biology of *A. gabonensis* in River Niger, Jebba. This would provide vital information for successful assessment and fishery management in Jebba and suitability of *A. gabonensis* for commercial production through aquaculture.

Materials and Methods

Study Area

The study area was River Niger, Jebba, located on latitude $9^{\circ} 35'$ and $9^{\circ} 50'$ N and longitude $9^{\circ} 30'$ and $5^{\circ} 00'$ E (Figure 1). Apart from fishing and livestock activities, the river is also used for hydro electrical, irrigational and navigational purposes.

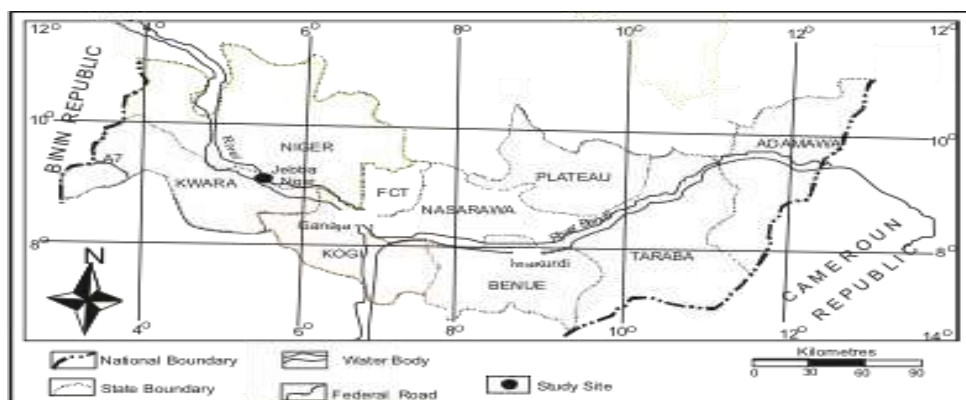


Figure 1: Map Showing Sample Collection Site at Jebba (Modified from Obaje, 2009)

Prawns were collected with the aid of fishermen and transported in iced box to the laboratory for further studies. Identification to species level was by keys of Powell (1982). The sexes were determined with the aid of specific morphological features that were peculiar to male and females of the prawns, such as appendix masculina, reproductive chamber and nubs on the first abdominal segment as demonstrated by Anetekhai (1990). Morphological measurements were done according to a model of Adete *et al.* (2013). Total body weight (g) was taken using a top loading electronic Metler balance (Model 59174) to the nearest gram. Fecundity was estimated by the gravimetric method of Fernandez *et al.* (1998). Egg diameter was measured to the nearest millimeter using a calibrated eye piece of a binocular microscope. The mean of the diameter of 10 eggs from a female was used as the diameter of individual egg per female. Data collected were analyzed using mini tab 14 computer software.

Results

Molting Statistics

Table 1 shows the molting statistics of *Atya gabonensis*. Total moulted specimens encountered were 712 out of 3,191 specimens. Highest percentage of moulted specimens were observed in March of both years (45.53% for March 2016 and 40.77% for March, 2017) while the lowest percentage of moulted specimens were seen in December of both years: 0.76% in December, 2016 and 1.24% in December, 2017

Table 1: Moulted Statistics of *A. gabonensis* at Jebba, January, 2016 to December, 2017

	Total no. of Samples	Total no. molted	Percentage molted
January 2016	155	9	5.81
February 2016	149	26	17.45
March 2016	582	265	45.53
April 2016	178	4	2.25
May 2016	120	8	6.67
June 2016	79	6	7.59
November 2016	83	2	2.41
December 2016	131	1	0.76
January 2017	149	5	3.36
February 2017	195	41	21.03
March 2017	731	298	40.77
April 2017	200	19	9.50
May 2017	86	11	12.79
June 2017	70	5	7.14
November 2017	122	10	8.20
December 2017	161	2	1.24
TOTAL	3191	712	

Sex Ratio

Out of a total number of 1461 of specimens in 2016, 1176 were males and 285, females, giving an overall sex ratio of 1:4.12 (Female: Male). There was significant difference ($P < 0.001$) in sex ratio in all the months from the expected 1:1. March had the highest ratio of Male to female (F:M, 1:6.78) and least sex ratio of Male to female was in May (F:M, 1:1.68). In 2017, a total of 1,616 specimens were investigated. About 1083 were males and 533 were females. A sex ratio of 1:2.29 (F:M) was the highest in November and the lowest ratio of 1:4.44 (F:M) was in June (Table 2).

Table 2: Sex Distribution of *A. gabonensis* from Jebba, January 2016 to December 2017

Year 2016	Female	Male	Sex ratio (F:M)	X ²	P-value	Year 2017	Female	Male	Sex ratio (F:M)	X ²	P-value
January	33	116	1: 3.52	38	0.001	January	47	92	1: 1.96	18.6	0.001
February	28	119	1: 4.25	53	0.001	February	65	115	1: 1.77	18.0	0.001
March	74	502	1: 6.78	305	0.001	March	221	485	1: 2.19	118.6	0.001
April	43	135	1: 3.14	48	0.001	April	60	119	1: 1.93	14.5	0.001
May	44	74	1: 1.68	6.53	0.011	May	29	51	1: 1.76	8.12	0.004
June	14	65	1: 4.64	32.9	0.001	June	27	39	1: 1.44	2.18	0.140
November	20	63	1: 3.15	22.3	0.001	November	35	80	1: 2.29	23.9	0.001
December	29	102	1: 3.52	40.7	0.001	December	49	102	1: 2.08	25	0.001
TOTAL	285	1176				TOTAL	533	1083			

Fecundity

One hundred (100) specimens were sampled for fecundity study. Fecundity varied from 550 – 3,6673, mean was $11,937 \pm 902$ (Table 3).

Table 3: Mean Fecundity of *A. gabonensis* from Jebba (January 2016 to December 2017)

Mean	11,937 ± 902
Minimum	550
Maximum	36,673
N	100

Correlation Matrix of Morphometric Parameters and Fecundity

Table 4 shows correlation matrix of some morphometric features and fecundity of female *A. gabonensis* from Jebba. Positive correlation was observed between fecundity and all the features recorded. The most correlated feature with fecundity was body weight ($r = 0.927$) while the least correlated features were carapace diameter and carapace length ($r = 0.768$).

Table 4: Correlation Matrix of Morphometric Parameters and Fecundity of *A. gabonensis* from Jebba (January 2016 to December 2017) (n=100)

	W	TL	CL	CD	AL
TL	0.80				
CL	0.68	0.82			
CD	0.67	0.75	0.83		
AL	0.72	0.89	0.92	0.86	
Fecundity	0.86	0.76	0.59	0.59	0.68

Keys: W=Weight; TL = Total length; CL = Carapace length; CD = Carapace diameter; AL = Abdomen length

Mean Egg Diameter

The egg size of *A. gabonensis* increased from 0.2 to 0.6 (Mean = 0.49 ± 0.009) (Table 5)

Table 5. Egg Diameter of *A. gabonensis* From Jebba (January 2016 to December 2017)

Mean	0.49 ± 0.009
Minimum	0.2
Maximum	0.6
N	100

Gonadosomatic Index (GSI) and Gonad Weight

Gonad weight and GSI of *A. gabonensis* from Jebba is presented in Table 6. gonad weight ranged from 0.005 to 0.11 (mean = 0.03 ± 0.003) for male, 0.003 to 0.21 (mean = 0.07 ± 0.003) for female. Gonadosomatic Index ranged from 0.09 to 0.97 (mean = 0.30 ± 0.02) for male and 0.06 to 0.82 (mean = 0.35 ± 0.01). There was a significant difference ($P < 0.05$) between the GSI and gonad weight of male and female.

Table 6: Mean Gonad Weight and Gonadosomatic Index of Different Sexes of *A. gabonensis* From Jebba (January 2016 to December 2017)

Parameter	Gonad weight		GSI			
Parameter	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Male	0.03 ± 0.003^b	0.005	0.11	0.30 ± 0.02^b	0.09	0.97
Female	0.07 ± 0.003^a	0.003	0.21	0.35 ± 0.01^a	0.06	0.82

Numbers in each cell are means ± standard error. Mean in the same column with different superscript differ significantly ($P < 0.05$).

Discussion

The higher percentage of molt in February and March may be due to increase in temperature which coincides with the onset of the rains and possible availability of food and in preparation for mating. FAO (2008) reported that under natural conditions, mating occurs throughout the year, although there are, sometimes, peaks of activity related to environmental conditions, and that in tropical areas molting and mating coincides with the onset of the rainy season, whereas in temperate region, these occur in the summer, which is the warmest season. The higher ratio of male in all the samples collected could be linked to the genetic attribute of *A. gabonensis*. This is in line with the report of Almeida *et al.* (2010) on *Atya. scrabra*. However, higher ratio of female to male has been reported in *Macrobrachium felicinum* and *M. vollehovenii* (Ukagwu and Deekae, 2016). Menon (1957) and Marioghae (1982) have reported equal sex ratio in *Macrobrachium* species. The fecundity in this study is higher than that of Obande *et al.* (2009) for the same species in River Benue, Makurdi. The differences may be related to environmental aspects, genetic variations of populations and predation on eggs by other aquatic organisms. The Fecundity/total length relationships show an increase in number of eggs with increasing female size; a similar situation was also observed by Albertoni *et al.* (2002) in *M. acanthurus*, Hart *et al.* (2003) in *M. felicinum* and Deekae and Abowei (2010) in *M. macrobrachion*. It could be perceived that the increase of fecundity with body size seems to be a rule that is applicable to many crustaceans. The GSI in this study is higher than that of Olele *et al.* (2012) in the Niger Delta. This may be an indication for high reproductive output of *A. gabonensis* in Jebba

Conclusion

Atya gabonensis suspected to breed in freshwater and could make an excellent candidate for aquaculture. Jebba is recommended for collection of *A. gabonensis* broodstock and seed at the onset of rainy season.

References

- Abowei, J.F.N., Deekae, S.N., Tawari, C.C., Allison, M.E. and Ngodigha, S.A. (2006). A review of shrimp fisheries in Nigeria. Pre-Joe publishers, Port Harcourt, Nigeria, Pp: 53.
- Adite, A., Abou, Y., Sossoukpe, E., Gbaguidi, M.H.A.G. and Fiogbé, E.D. (2013). Meristic and Morphological Characterization of the Freshwater Prawn, *Macrobrachium macrobrachion* (Herklots, 1851) from the Mono River-Coastal Lagoon System, Southern Benin (West Africa): Implications for Species Conservation. *International Journal of Biodiversity and Conservation*, 5(11): 704-714. doi: 10.
- Albertoni, E., Palma-Silva, C. and Esteves, F. (2002). Fecundity of *Macrobrachium acanthurus* (Eiegmann, 1836 (Decapoda: Palaemonidae) in a Tropical Coastal Lagoon Subjected to Human Impacts (Mace, Brazil). *Acta Limnologica Braziliensia*, 14(1): 71-80.
- Almeida, A.O., Mossolin, E.C. and Luz, J.R. (2010). Reproductive biology of the freshwater shrimp *Atya scabra* (Leach, 1815) (Crustacea: Atyidae) in Ilhéus, Bahia. *Brazil Zoological Studies*, 49: 243–252.
- Anetekhai, M.A. (1986). Aspects of the bioecology of the African River prawn (*Macrobrachium vollehovenii*) in Asejire Lake, Ph.D. Thesis submitted to University of Ibadan, pp. 225.

- Anetekhai, M.A. (1990). Sexual Dimorphism and Egg Production in Africa River Prawn *Macrobrachiumvollenhovenii* from AsejireLake, Oyo State, Nigeria. *Nigerian Journal of Science*, 24: 147-151.
- Deekae S.N., J.F. Abowei. (2010). The Fecundity of *Macrobrachium macrobrachion* (Herklots, 1851) from Luubara Creek, Ogoni Land, Niger Delta, Nigeria. *International Journal of Animal and Veterinary Advances*, 2(4): 148–154.
- FAO (2008) Fishstat Plus (v. 2.32) issued 11.03.2008. FAO, Rome
- Fernandez–Palacios, H.Q., Robaina, M.L. and Valencia, A. (1998). Combined Effect of Dietry a–tocopherol and n–3 HUFA on Eggs Equality of Gilthead Sea Bream Brood Stock (*Sparus aurata*). *Aquaculture*, 161:475–476.
- Hart, A.I., Ansa E. J. and Sekibo, I. (2003). Sex Ratio, Sexual Dimorphism and Fecundity in Pond Reared Niger River Prawn, *Macrobrachiumfelicinurn* (Ilolthuis, 1949). *The Zoologist*, 2(1): 56-61.
- Marioghae, I.E. (1982). Notes on the biology and distribution of *M. vollenhovenii*, *M. macrobrachion* in the Lagos Lagoon. *Revue de ZoologieAfricaines*, 96(3): 493 - 508.
- Menon, M.K.(1957). Contribution on the biology of penaeid prawn of the south west coast of India. Sex ratio and movements. *Indian Journal of Fish*, 4 (1): 62–74.
- Nwosu, F. M. (2009). Aspects of the biology of the Gabon Shrimp *Atyagabonensis*. *Journal of Fisheries International*, 4(4):58-61.
- Obande, R. A. (2006). The biology of *Atyagabonensis* from Lower River Benue. Ph.D. Thesis, University of Lagos, Lagos. 70pp.
- Okayi, R. G., Ataguba, G. A. and Nyishagba, O. (2010). Biology of two freshwater prawns (*Palaeomonetes africanus* and *Demoscarisbislineata*) from the Mu River, Makurdi-Benue State. *Journal of Animal and Plant Science*, 5(3): 544-549.
- Obaje, N. G. (2009). Geology and Mineral Resources of Nigeria, London: Springer Dordrecht Heidelberg, Pp5-14.
- Okayi, R. G., Ataguba, G. A. and Nyishagba, O. (2010). Biology of two freshwater prawns (*Palaeomonetes africanus* and *Demoscarisbislineata*) from the Mu River, Makurdi-Benue State. *Journal of Animal and Plant Science*, 5(3): 544-549.
- Olele, N. F., Tawari-Fufeyin, P. and Okonkwo, J.C. (2012). Reproductive biology of freshwater prawn *Macrobrachiumvollenhovenii* (Herklot, 1857) caught in Warri River. *ArchivaZootechnica*, 15 (4): 41-57.
- Powell, C. B. (1982). Fresh and Brackish water prawns of economic importance in Niger Delta. In proceedings of 2nd Conference of Fisheries Society of Nigeria, Calabar, 22-24 Jan 1982, pp 254-285.
- Solomon, S.G., Obande, R.A. and Imgbian, T.D. (1999). Aspects of Biology and Racial Characteristics of Gabon Shrimp, *Atyagabonensis* in River Benue. *Journal of Agriculture, Science and Technology*9-11: (1 and 2).
- Ukagwu, J. I. a nd Deekae, S. N. (2016). Sex population structure of *Macrobrachium felicinum* and *Macrobrachiumvollenhovenii* in the Akor river, IbereIkwuano, Abia State. *International Journal of Fisheries and Aquatic Studies* 4(4):19-23.
- Zabbey, N., Erondy, E. S. and Hart, A. I. (2010). Nigeria and the prospect of shrimp farming: critical issues. *Livestock Research for Rural Development*. Volume 22, Article #198. Retrieved January 17, 2016, from <http://www.lrrd.org/lrrd22/11/zabb22198.htm>

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Comparative Morphometric Relationship between Freshwater Prawn: *Atya gabonensis* and *Macrobrachium felicinum* from Lower River Benue, Makurdi, Nigeria

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Abstract

A comparative morphometric relationship study between *Atya gabonensis* and *Macrobrachium felicinum* in the lower River Benue, Makurdi was carried out. A total of 1489 freshwater prawns were collected, comprising 784 males and 373 females *A. gabonensis* and 69 males and 263 females *M. felicinum* species. Prawns were identified using taxonomic keys, 14 and 19 morphometric characters were measured for *A. gabonensis* and *M. felicinum* respectively. This study revealed that *A. gabonensis* morphometric characters were strongly positively related with a percentage variance (69.01%) in the PCA biplot (component 1) compared to a lower coefficient of correlation values observed for *M. felicinum* with a lower percentage variance (27.16%). *Atya gabonensis* males had highest body weight and morphometric measurements compared to all other groups. Moreover, males' morphometric measurements were higher than females. Conclusively, *A. gabonensis* body weight and morphometric measurements were significantly higher than *M. felicinum*, however, both species could be good prawn aquaculture candidates and all male production is therefore recommended.

Keywords: Prawns, Morphometric, , Sex, Benue River, Benue State, Nigeria

Introduction

Despite the importance of prawns in the provision of quality protein, foreign exchange earnings and employment generation, their culture is still in its infant stage in Nigeria. There are many species of prawns which are found across the various water bodies in Nigeria belonging to family Atyidae, Alpheidae, Hippolytidae, and Palaemonidae, which include good candidates for aquaculture (Powell, 1982). Powell (1983) mentioned three important species of freshwater prawn that dominate Nigerian inland water as *Macrobrachium felicinum*, *M.vollenhovenii* and *M. macrobranchion*. *Atya gabonensis* was also reported to be harvested in a small scale in northern Nigeria (Reed, 1967). The major challenges limiting the culture development of these prawns in Nigeria is scarcity of post larvae for stocking grow-out ponds (Anyanwu *et al.*, 2012). This is due to lack of knowledge on the biology of Nigerian indigenous prawns. The biology of these prawns has not been fully documented, knowledge on their biology is *sine qua non* for their successful culture. Hence, this study is designed to provide necessary information on the morphometrics of *M.felicinum* and *A.gabonensis* in the Lower River Benue, Makurdi.

Materials and Methods

Study Area

The Lower River Benue, Makurdi (Figure 1) is located on latitude 7° 55' and 7° 56' North of equator and longitude 8° 20' and 8° 40' East of the Greenwich meridian. River Benue originates from Adamawa hills and flows from the Southern part of Cameroon through Makurdi and Southwards to Lokoja where it forms a confluence with River Niger. At bank full, the river is about 129,000 hectares with as much as 25m difference between high and low water levels.



Figure 1: Map of Lower River Benue showing Makurdi, the sampling site. Source: Wikipedia.com (2015)

Prawn Sample Collection, Identification and morphological measurements

A total of 1489 prawns were collected by the help of fishermen and transported in ice box to the laboratory for further studies. Identification to species level was by keys of Powell (1982). The sexes were determined with the aid of specific morphological features that were peculiar to male and females of the prawns, such as appendix masculina, reproductive chamber and nubs on the first abdominal segment as demonstrated by Anetekhai (1990). Total body weight (g) was taken using a top loading electronic Metler balance (Model 59174). Morphological measurements were done according to the method described by Adete *et al.* (2013), TL = Total Length, CL = Carapace length, CD = Carapace diameter, RL = Rostral length, AL = Abdomen length, TSL = Telson length, UL = Uropod length, PH = Height of Pleuron of 2nd abdominal segment, PW = Width of pleuron of 2nd abdominal segment, LM = Length of merus of 3rd walking leg, RC = Length of carpus of 3rd walking leg, RP = Length of palm of 3rd walking leg, RF = Length of finger of 3rd walking leg, LRM = Length of Right merus of second walking leg; LRC = Length of Right carpus of second walking leg; LRP = Length of right palm of second walking leg; LRF = Length of right finger of second walking leg. LLM = Length of left merus of second walking leg; LLC = Length of left carpus of second walking leg; LRP = Length of right left palm of second walking leg; LRF = Length of left finger of second walking leg for M were measured.

Data analysis

Multivariate analysis (Principal component analysis) (PCA)) was used to establish morphometric relationships across species using PAST statistical software, students' t-test and analysis of variance was used to compare morphometrics between sexes using SPSS IBM version 24.

Results and Discussion

Macrobrachium felicinum and *A. gabonensis* collected from Lower River Benue, all measured morphometric characters were strongly positively related to each other with the exception of DRS and CD in *M. felicinum* (Fig. 2a, 3a). From the PCA biplot, component 1 attributes showed a higher percentage variance (69.01%), with majority of morphometrical parameters clustering in quadrant 2 and 3 (Fig 2a), while coefficient of correlation (r) from PCA loadings indicates strong positive relationships among morphometric characters of *A. gabonensis* (Fig. 2b). Fig. 3a shows a PCA biplot of *M. felicinum* morphometric characters relationships, using component 1 (27.16% variance) and component 2 (13.40% variance), all morphometric characters clustered in second and third biplot quadrant indicating relationship amongst characters; W, TL, CL, LRM, LRC, LRF, PH and LLC showed strong positive correlation while CD and DRS had no relationship with other characters (Fig 3b). The male and female of *M. felicinum* and *A. gabonensis* prawn morphometric characters are presented in Fig. 4a to 4c respectively, body weight and other morphometric characters differed between male and female in both species. *Atya* male morphometric characters were significantly higher compared to *Atya* female and *M. felicinum* male and female.

Morphometric studies have been proven valuable in providing insight into several factors that may confound the analytical results such as sexual dimorphism, timing of sampling, and allometric growth (Chen *et al.*, 2015). Morphometric findings have been widely employed for taxonomic purposes in the freshwater prawn (Mariappan and Balasundaram, 2004). In this present study, variation in the morphometric relationships obtained between the male and female within and between species may have resulted from variation in food, population density, environmental conditions and genetic makeup of the species (Mariappan and Balasundaram, 2004). Also, there is a great sexual dimorphism between sex within and between the two species.

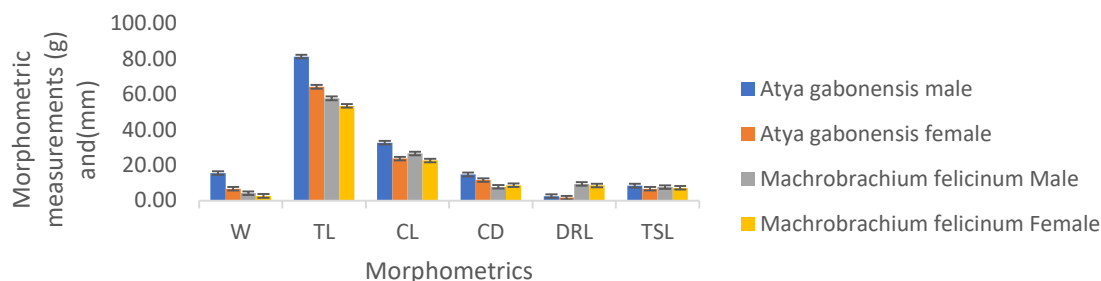


Fig 4c. Morphometric parameters of male and female *A.gabonensis* and *M. felicinum* collected from Lower River Benue, Makurdi

Conclusion

Atya gabonensis body weight and morphometric measurements are significantly higher than *M. felicinum*, however both species could be good prawn aquaculture candidates if their hatchery system are adequate. moreover, all male production is therefore recommended.

References

- Adite, A., Abou, Y., Sossoukpe, E., Gbaguidi, M.H.A.G. and Fiogbé, E.D. (2013). Meristic and Morphological Characterization of the Freshwater Prawn, *Macrobrachium macrobrachion* (Herklots, 1851) from the Mono River-Coastal Lagoon System, Southern Benin (West Africa): Implications for Species Conservation. *International Journal of Biodiversity and Conservation*, 5(11): 704-714. doi: 10.
- Anetekhai, M.A. (1990). Sexual Dimorphism and Egg Production in Africa River Prawn *Macrobrachium vollenhovenii* from Asejire Lake, Oyo State, Nigeria. *Nigerian Journal of Science*, 24: 147-151.
- Anyanwu, P.E., Ayinla, O.A., Ebonwu, B.I., Ayaabu-Cookey, I.K., Hamzat, M.B., Ihimekpen, A.F., Matanmi, M.A., Afolabi, E.S., Ajijo, M.R. and Olaluwoye, B.L. (2012). Culture Possibilities of *Penaeus monodon* in Nigeria. *Journal of Fisheries and Aquatic Science*, 6:499-505.
- Chen, P.C. Tzeng T.D., Shih, C.H., Chud, T.J., Lee, Y.C. (2015). Morphometric variation of the oriental river prawn (*Macrobrachium nipponense*) in Taiwan, *Limnologica* 52: 51-58.
- Mariappan, P. and Balasundaram C. (2004). Studies on the Morphometry of *Macrobrachium nobilii* (Decapoda, Palaemonidae), *Brazilian Archives of Biology and Technology*, 47(3): 441-449.
- Powell, C. B. (1982). Fresh and Brackish water prawns of economic importance in Niger Delta. In proceedings of 2nd Conference of Fisheries Society of Nigeria, Calabar, 22-24 Jan 1982, pp 254-285.
- Powell, C.B. (1983). The genus *Macrobrachium* in West Africa. I: *M. thysi*, a new large-egged species from the Ivory Coast (Crustacea Decapoda Palaemonidae). *Revue de Zoologie Africaine*, 94: 317-325.
- Reed, W. (1967). Fisheries of Northern Nigeria. Ministry of Agriculture of Northern Nigeria. 157pp.
- Tizkar, B. Seidavi A., and Ponce-Palafox, J.T. (2017). Study of some morphometric, meristic characters and lengthweight relationship in wild and domestic populations of the eastern river prawn, *Macrobrachium nipponense* (De Haan, 1849) (Crustacea: Decapoda: Palaemonidae), in Iranian Basin of the Caspian Sea, *Iranian Journal of Fisheries Sciences* 19(4): 2173-2184.
- Torres M. V., Giri F. and Collins P. A. (2014). Geometric morphometric analysis of the freshwater prawn *Macrobrachium borellii* (Decapoda: Palaemonidae) at a microgeographical scale in a floodplain system, *Ecological Recourses*, 29: 959-968.

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Growth Pattern of Freshwater Prawn (*Atya gabonensis* Giebel, 1875 (Crustacea: Atyidae) In the Lower River Benue, Makurdi, Nigeria

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Abstract

About 1,030 Specimens of *Atya gabonensis* were collected from Lower River Benue, Makurdi, with the aid of fishermen from January to August 2015. These were transported in ice box to the laboratory for further studies. Length - weight relationship and condition factor were calculated using standard methods. The results from the study indicated that allometric coefficient 'b' was highest in August (3.114) and lowest in February (1.119). Mean condition factor (K) was highest in May (2.99 ± 0.08) and lowest in March (2.25 ± 0.05). Carapace length ranged from 0.90cm in February to 6.20cm in June (mean = 2.31 ± 0.04 cm). Total length ranged from 3.0cm in February to 14.4 cm in January (mean = 8.55 ± 0.06 cm) and body weight ranged from 1.50g in March to 73.0g in January with mean value of 18.03 ± 0.38 g. Correlation ranged from 0.8025 in June to 0.9550 in January. It was concluded that *A. gabonensis* is well adapted to the freshwater body of River Benue and it is believed to be a good candidate for prawn culture in freshwater systems in Nigeria.

Keywords: Lower River Benue, Freshwater prawn, Length-weight relationship, condition factor, Allometric growth

Introduction

Atya gabonensis are fresh water prawn which has dominated the Nigerian inland waters. Its presence was reported in the northern Nigeria (Reed, 1976) and River Niger (Motwani and Kanwai, 1970). This species is amphi-atlantic, occurring from the Democratic Republic of Congo through to Senegal, as well as in Venezuela, Suriname and Brazil (Mantelatto, 2012). Prawns have good nutritional value and generate substantial economic benefits (FAO, 2008). But production from Nigeria is mostly wild-caught and in small quantity (about 12,000 tonnes annually) (Zabbey *et al.*, 2010). It is important to develop prawn culture in Nigeria to increase production for improved nutrition, foreign exchange earnings and employment generation. Hence vast knowledge of the biology and suitability of indigenous species for culture are important.

A few studies have been done on the biology of *A. gabonensis* in Nigeria. These include Powell (1982), Solomon *et al.* (1999), Nwosu (2009) and Obande and Kusemuji (2006). This study aimed to provide information on the length-weight relationship and condition factor of *A. Gabonensis* in Lower River Benue. This would provide basic information for sustainable management of the stock and possible culture of the species for increased prawn productivity. The result of this study could also be compared with and provide update on the reports of Solomon *et al.* (1999), Okayi and Iorkyaa (2004) and Obande and Kusemuji (2006).

Materials and Method

Study Area

The study area, Lower River Benue, Makurdi (Figure 1) is located on latitude 7° 55' and 7° 56' North of equator and longitude 8° 20' and 8° 40' East of the Greenwich meridian. River Benue originates from Adamawa hills and flows from the Southern part of Cameroon through Makurdi and Southwards to Lokoja where it forms a confluence with River Niger. At bank full, the River is about 129,000 hectares with as much as 25m difference between high and low water levels.



Figure 1: Map of Lower River Benue showing Makurdi, the sampling site. Source: Wikipidia.com (2015)

Prawn Sample Collection and Identification

About 1,030 prawns were collected by the help of fishermen and transported in ice box to the laboratory for further studies. The prawns were identified to the species level, using keys provided by Powell (1982).

Measurements of Carapace Length, Total Length and Weight

Carapace length was measured by the use of a vernier calipers as the distance from the tip of the rostrum to the end of the carapace. The total length was measured, using a meter rule (cm) as the distance from the tip of the telson to the tip of the dorsal teeth. The total body weight (g) was taken using a top loading electronic balance (Model 59174) to the nearest gram.

Length – Weight Relationship

The length/weight relationship was computed by the equation of Bagenal (1978). The condition factor was calculated using the equation of Fulton's condition factor by Ricker (1975).

Results

Monthly variations in morphometric characteristics of *A. gabonensis* in Table 1 showed that the lowest mean carapace length of 2.93 ± 0.07 cm was in February and the highest value in January (4.16 ± 0.07 cm). Mean total length was lowest in February (6.98 ± 0.14) and highest in June (9.59 ± 0.15). The mean lowest body weight (10.24 ± 0.61) was recorded in March and the highest (27.80 ± 1.29 g) in April.

Monthly length-weight relationship and condition factor is in Table 2. The 'b' value of the regression equation ranged from 1.119 in February to 3.114 in August. Growth pattern revealed isometric growth in March and allometric in other months. Negative intersections were observed for 'a' all through the months, with highest value observed in August (-1.7349). Condition factor was higher in May (2.99) compared to other months ($P < 0.05$). Lower condition factor was in January, March, June and August.

Overall morphometric parameters and condition factor for male, female and combined sexes is shown in Table 3. Total length ranged from 3.00 – 14.40 cm (8.55 ± 0.06 cm), carapace length ranged from 0.90 – 6.20 cm (3.56 ± 0.03 cm), body weight ranged from 0.70 – 73.00 g (18.03 ± 0.38 g) and condition factor (K) ranged from 1.03 – 6.68 with a mean value of 2.50 ± 0.02 . The correlations of morphometric parameters of female (Table 4) revealed high correlation between carapace length and total length ($r = 0.789$), carapace length and weight ($r = 0.641$), and total length and weight ($r = 0.837$), however condition factor only correlated significantly with weight ($r = 0.550$).

In morphometric parameters of male specimens (Table 5), higher correlation levels were recorded between carapace length with total length ($r = 0.963$), carapace length and weight ($r = 0.890$) and total length and total weight ($r = 0.926$) compared to the female. Though result obtained shows significant correlation between condition factor and weight, correlation value was very low ($r = 0.254$) compared to female. Negative correlation was observed between condition factor and carapace length ($r = -0.045$) and total length ($r = -0.031$).

Table 1: Monthly Variations in Morphometric Characteristics of *A.gabonensis* in Lower River Benue from January 2015 to August 2015

Month	No.	Carapace length (cm)			Total Body Length (cm)			Total Body Weight (g)		
		Min	Max.	Mean±S.E	Min	Max.	Mean±S.E	Min.	Max.	Mean±S.E
Jan.	160	1.50	5.90	4.16±0.07	4.60	13.20	9.74±0.14	1.50	59.20	23.88±1.07
Feb.	125	1.20	4.90	2.93±0.07	3.50	10.90	6.98±0.14	0.70	33.10	11.02±0.72
March	151	0.90	5.90	3.19±0.07	3.00	11.50	7.33±0.13	0.80	36.20	10.24±0.61
April	142	2.30	5.50	3.57 ± 0.06	5.50	12.80	8.48 ± 0.13	3.50	61.10	27.80 ± 1.29
May	120	1.90	6.10	3.65±0.08	4.70	13.60	8.76±0.16	3.10	52.10	18.05±0.97
June	104	1.50	6.20	3.67 ± 0.11	7.50	14.40	9.59 ± 0.15	10.00	73.0	17.18 ± 0.85
July	99	2.10	5.90	3.75±0.08	5.90	12.60	8.94±0.16	4.80	52.10	19.28±1.09
August	91	1.20	5.90	3.59±0.11	3.50	13.20	8.75 ± 0.22	0.70	51.00	19.14 ± 1.35

Table 2: Monthly Length-Weight Relationship and Condition Factor of *Atyagabonensis* collected from Lower River Benue from January to August 2015

Month	a	b	r	Condition factor
Jan	-1.4655	2.838	0.9550	2.34 ± 0.02 ^{de}
Feb	-0.479	1.119	0.9231	2.74 ± 0.06 ^b
Mar	-1.6728	3.012	0.8501	2.25 ± 0.05 ^e
Apr	-1.5175	2.912	0.8961	2.56 ± 0.04 ^c
May	-1.5100	2.969	0.7543	2.99 ± 0.08 ^a
June	-1.4673	2.823	0.8025	2.39 ± 0.13 ^{de}
July	-1.4031	2.781	0.9407	2.48 ± 0.03 ^c
August	-1.7349	3.114	0.9479	2.39 ± 0.05 ^{de}

Means in the same column with different superscripts differed significantly (P<0.05)

Table 3: Morphometric Characteristics and Condition Factor of Males, Females and Combined Sexes of *Atyagabonensis* in Lower River Benue from January to August 2015 (n=1030)

Sexes	Carapace Length (cm)			Total Length (cm)			Weight (g)			Condition Factor (K)		
	Min.	Max	Mean±S.E	Min.	Max.	Mean±S.E	Min.	Max.	Mean±S.E	Min.	Max	Mean±S.E
Male	1.70	6.20	3.93 ± 0.037	3.90	14.40	9.21 ± 0.08	1.90	73.00	21.74 ± 0.52	1.03	6.50	2.47 ± 0.02
Female	0.90	5.20	2.30 ± 0.04	3.00	10.90	7.52 ± 0.07	0.70	41.00	12.23 ± 0.38	1.03	6.68	2.55 ± 0.03
Comb. Sexes	0.90	6.20	3.56 ± 0.03	3.00	14.40	8.55 ± 0.06	0.70	73.00	18.03 ± 0.38			

Table 4: Correlation Matrix between Morphometric Parameters of *Atyagabonensis* Female collected from Lower River Benue from January to August 2015

	Carapace length	Total length	Weight
Total length	0.789***		
Weight	0.641***	0.837***	
Condition factor	0.061	0.126	0.550***

Cell contents: Pearson correlation. P-value *** Significant (P<0.001)

Table 5: Correlation Matrix between Morphometric Parameters of *Atyagabonensis* Male collected from Lower River Benue from January to August 2015

	Carapace length	Total length	Weight
Total length	0.963***		
Weight	0.890***	0.926***	
Condition factor	-0.045 0.257	-0.031 0.434	0.254***

Cell contents: Pearson correlation. P-value *** Significant (P<0.001)

Discussion

The isometric growth observed is an indication that increase in weight is proportional to increase in length, while the allometric growth suggests that the prawns have more weight increment in relation to length increment in those months. Gopalakrishnan *et al.* (2014) and Sun *et al.* (2015) recorded similar phenomenon. This could be attributed to fluctuation in availability of food and environmental condition. Fluctuation in condition factor observed was also reported by Thomas (1975) and Rao, (1969) on *Penaeus semisulcatus* and *Macrobrachium rosenbergii* respectively, and was attributed to availability of food in the different months and developmental stages of the gonads. The higher condition factor in female might be related to the increased capacity of females in storing energy/fat to use it during gonadal maturation, as well as the larger size and weight of the ovaries in comparison with testis, Lira *et al.* (2012) reported similar event. The results of the length-weight relationship and condition factor obtained from this study is within the range reported by Solomon *et al.* (1999), Okayi and Iorkyaa (2004) and Obande and Kusemuji (2006), but higher than that reported by Powell (1982) and Nwosu (2009). This may be due to lack of exploitation of this species in the North-central part of Nigeria, and the presence of food, absence of predators and good environmental conditions.

Conclusion

Atya gabonensis well adapted to the freshwater body of River Benue and it is suspected to make a good candidate for prawn culture in freshwater system in Nigeria.

References

- Bagenal, T.B. (1978). Aspects of fish fecundity. In Ecology of Fish Production (Ed. Gerking S.D.), Blackwell, Oxford: Blackwell Scientific Publications. 519pp.
- FAO (2008). Global Study of Shrimp Fisheries. FAO fisheries technical paper, 475pp
- Gopalakrishnan, A, Rajkumar, M, Rahman, M.M., Sun, J, Antony, P.J, Venmathi Maran, .B.A, Trilles, J.P. (2014). Length-weight relationship and condition factor of wild, grow-out and 'loose-shell affected' giant tiger shrimp, *Penaeus monodon* (Fabricius, 1798) (Decapoda: Penaeidae). *Journal of Applied Ichthyology*, 30:251–253.
- Lira, J.J.P.R., Calado, T.C.S. and Araújo, M.S.L.C. (2012). Condition factor of *Goniopsis cruentata* (Crustacea, Brachyura, Grapsidae) from Mundaú/Manguaba estuarine complex, Alagoas, *Brazilian Iheringia, Série Zoologia*, 102(3): 285–291
- Mantelatto, F.L. and R.B. Garcia. (1999). Reproductive potential of the hermit crab *Calcinus tibicen* (Crustacea, Anomura) from Ubatuba, São Paulo, *Brazilian Journal of Crustacean Biology*, 19(2): 268-275.
- Motwani M. P. and Kanwai, Y. (1970). Fish and fisheries of the coffer-dammed right channel of River Niger and Kainji. In: Kainji Lake Studies [Visser S.A. (ed)] I. Ecology. Ibadan University Press, Ibadan: 27-48
- Nwosu, F. M. (2009). Aspects of the biology of the Gabon Shrimp *Atyagabonensis*. *Journal of Fisheries International*, 4(4):58-61.
- Obande, R. A. and Kusemiju, K. (2006). Food and feeding habit of *Atyagabonensis* from Lower River Benue in Northern Nigeria. *West African Journal of Applied Ecology* 13: 19-18.
- Okayi, R. G. and Iorkyaa, A. (2004). Length-weight relationship and condition of fresh water shrimp *Atyagabonensis* and *Macrobrachium felcinium* from the Mu River, Makurdi, Nigeria. *Animal Research International*, 1(3):153-154.
- Powell, G.E. (1982). Fresh and Brackish water prawns of economic importance in Niger-Delta. In proceedings of 2nd Conference of Fisheries Society of Nigeria, Calabar. 22-24 Jan 1982.
- Reed, W. (1967). Fisheries of Northern Nigeria. Ministry of Agriculture of Northern Nigeria. 157pp.

- Ricker, W.E. (1975). Competition and interpretation of biological statistics of fish population. Bulletin of the Fisheries. Research. Board of Canada, 191: 382pp.
- Solomon, S. G.; Obande, R. A. and Imgbian, T. D.(1999). Aspects of Biology and Racial Characteristics of Gabon Shrimp, *Atyagabonensis* in River Benue. *Journal of Agriculture, Science and Technology*, 9-11, No 1
- Thomas, M.M. (1975). Age and growth, length weight relationship and relative condition factor of *Penaeus semisulcatus* De Haan. *Indian Journal of Fisheries*, 22: 133-142.
- Zabbey, N., Erondy, E. S. and Hart, A. I. (2010). Nigeria and the prospect of shrimp farming: critical issues. *Livestock Research for Rural Development*. Volume 22, Article #198. Retrieved January 17, 2016, from <http://www.lrrd.org/lrrd22/11/zabb22198.htm>

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Comparative Assessment of Aspects of Reproductive Biology of Two Freshwater Prawns, *Macrobrachium felicinum* (Holthuis, 1949) and *Atya gabonensis* (Giebel, 1875) In River Benue, Makurdi, Nigeria

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Abstract

This work was designed to determine and compare sex ratio, fecundity, egg diameter and gonadosomatic index of *M. felicinum* and *A. gabonensis* in Lower River Benue from January to December, 2016. A total of 295 *M. felicinum* were sampled with an overall sex ratio of 8.52:1(F:M). The highest sex ratio of female to male (12:1 F: M) was in August while the least was in September (5.00:1 F: M). About 2413 *Atya gabonensis* were collected with an overall sex ratio of 1:2.11. Fecundity varied from 230 to 69,782 eggs (15,133 $\pm$ 1,222) in *M. felicinum* and 4,300 to 8,600 eggs *A. gabonensis*. Stronger correlation was observed between fecundity and total length ($r=0.64$ in *M. felicinum* and 0.87 in *A. gabonensis*). Mean egg diameter of *A. gabonensis* was 0.46 ± 0.0 mm and that of *M. Felicinum* was 0.44 ± 0.03 . *Macrobrachium felicinum* showed higher Gonadosomatic Index (0.58 ± 0.041) than *A. gabonensis* (0.33 ± 0.009). Both species, *A. gabonensis* and *M. felicinum* were recommended as good candidates for aquaculture as their seeds are readily available in the Lower River Benue. *M. felicinum* was suggested to have more reproductive output than *A. gabonensis*.

Key words: freshwater prawn, sex ratio, fecundity, gonadosomatic index, egg diameter, Lower River Benue

Introduction

Shrimps and prawns are of great economic importance in the provision of food, foreign exchange earnings and employment (FAO, 2008). The presence of prawns in Nigeria's fresh and brackish water has been reported by many authors including Anetekhai (1986) and Anetekhai (1990). Nigeria produces and even exports these fisheries resource but in minimal quantity, about 12,000 tonnes annually (Zabbe et al., 2010). The global markets for shrimp and prawns are increasing by three percent annually, largely due to increased consumption in the US, Europe and Japan (FAO, 2008). There is need for Nigeria to step up its production to meet the rising demand at local and international levels. In order to avoid over exploitation of the natural resources, commercial culture of prawn is the best option. Currently, *Macrobrachium rosenbergii* is the only freshwater prawn used in commercial farming, since its biology and farming technology are well known compared to other species (Coelho et al., 1982). *Macrobrachium felicinum* and *Atya gabonensis* are among the freshwater prawns reported to occupy the Nigerian main rivers and tributaries (Reed et al., 1967). Nigeria is lagging behind in prawn culture. The knowledge of reproductive capacity of these two species, abundant in our fresh water bodies is important for evaluation of their potentials for commercial farming, as well as an estimation of the stock size of natural population. The aim of this work is to determine and compare sex ratio, fecundity, egg diameter and gonadosomatic index of *M. felicinum* and *A. gabonensis* in the Lower River Benue, Makurdi, Nigeria.

Materials and Methods

The sample area was River Benue in Makurdi, which is located on latitude $7^{\circ} 55'$ and $7^{\circ} 56'$ North of equator and longitude $8^{\circ} 20'$ and $8^{\circ} 40'$ East of the Greenwich meridian (Figure 1). River Benue originates from Adamawa hills and flows from the Southern part of Cameroon through Makurdi and Southwards to Lokoja where it forms a confluence with River Niger. At bank full, the River is about 129,000 hectares with as much as 25m difference between high and low water levels.



Figure 1: Map of Lower River Benue showing Makurdi, the sampling site. Source: Wikipedia.com (2015)

Prawns were collected with the aid of fishermen and transported in iced box to the laboratory for further studies. Identification to species level was done by keys of Powell (1982). The sexes were determined with the aid of specific morphological features that were peculiar to male and females of the prawns, such as appendix masculina, reproductive chamber and nubs on the first abdominal segment as demonstrated by Anetekhai (1990). Morphological measurements were done according to a model of Adete *et al.*, (2013). Total body weight (g) was taken using a top loading electronic Metler balance (Model 59174). Fecundity was estimated by the gravimetric method of Fernandez *et al.* (1998). Egg diameter was measured to the nearest millimeter using a calibrated eye piece of a binocular microscope. The mean of the diameter of 10 eggs from a female was used as the diameter of individual egg per female.

Results

Sex Distribution

A total of 295 *M. felicinum* was sampled, males were 31 and females were 264 (Table 1). An overall ratio of 8.52: 1(F:M) was observed. The highest number of females to males (F:M of 12:1) was in August and the least sex ratio of female to male was in September (5.00: 1). There was no significant difference ($p > 0.001$) in January, February, March and September. About 2413 *A. gabonensis* were sampled males were 1636 and females were 777 with an overall sex ratio of 1:2.11 (Table 2). There was significant difference ($p < 0.001$) in all the months with the highest sex ratio of 1:5.35(F:M) in November and 1:1.59 in April. Positive correlation was observed between fecundity and other features measured except with CD in *M. felicinum*. Stronger correlation was observed between Fecundity and total length ($r = 0.64$) in *M. felicinum* and (0.87) in *A. gabonensis* (Tables 4 and 5)

Table 1: Sex Distribution of *M. felicinum* (January to September, 2016)

Month	Female	Male	Sex ratio (F:M)	X ²	P-value
January	17	3	5.67: 1	0.50	0.480
February	10	1	10.00: 1	1.80	0.180
March	32	3	10.67: 1	0.00	1.000
April	28	3	9.33: 1	4.57	0.033
May	56	7	8.00: 1	9.32	0.002
June	37	4	9.25: 1	7.2	0.007
July	50	6	8.33: 1	9.97	0.002
August	24	2	12.0: 1	8.07	0.005
September	10	2	5.00: 1	1.29	0.257
TOTAL	264	31			

Table 2: Sex Distribution of *A. gabonensis* from Makurdi (January to December, 2016)**Correlation matrix of morphometric parameters and fecundity**

Year 2017	Female	Male	Sex ratio (F:M)	X ²	P-value
January	173	354	1 : 2.05	62.2	0.001
February	98	167	1 : 1.70	17.9	0.001
March	110	197	1 : 1.79	24.7	0.001
April	251	398	1 : 1.59	33.3	0.001
May	65	195	1 : 3.00	65.0	0.001
June	9	42	1 : 4.67	21.4	0.001
November	31	166	1 : 5.35	92.5	0.001
December	40	117	1 : 2.93	37.8	0.001
TOTAL	777	1636			

Table 3: Mean Fecundity of *M. felicinum* and *A. gabonensis*

Species	Mean	Minimum	Maximum
<i>M. felicinum</i>	15,133 ± 1222	230	69,782
<i>A. gabonensis</i>	6,450 ± 2150	4,300	8,600

Table 4: Correlation Matrix of Morphometric Parameters and Fecundity of *M. felicinum*

	W	TL	CL	CD	AL
TL	0.29				
CL	0.26	0.81			
CD	0.03	-0.15	-0.15		
AL	0.23	0.48	0.54	-0.11	
Fecundity	0.42	0.64	0.57	-0.00	0.14

Keys: W=Weight; TL = Total length; CL = Carapace length; CD = Carapace diameter; AL = Abdomen length

Numbers in each cell are means ± standard error. Mean in the same column with different superscript differ significantly (P<0.05).

Table 5. Correlation Matrix of Morphometric Parameters and Fecundity of *A. gabonensis*

	W	TL	CL	CD	AL
TL	0.63				
CL	0.58	0.88			
CD	0.56	0.71	0.80		
AL	0.56	0.87	0.99	0.82	
Fecundity	0.65	0.87	0.78	0.64	0.78

Keys: W=Weight; TL = Total length; CL = Carapace length; CD = Carapace diameter; AL = Abdomen length

Egg Diameter

There was a significant difference (P<0.05) between the egg size of *A.gabonensis* and *M.Felicinum* (Table 6). *Atyagabonensis* had larger eggs (0.46 ± 0.01 mm) than *M. Felicinum* (0.44 ± 0.03).

Table 6: Mean Egg Diameter of *A. gabonensis* and *M. Felicinum*

Parameter	Mean	Minimum	Maximum	N
<i>A. gabonensis</i>	0.46 ± 0.01 ^a	0.2	0.6	210
<i>M. Felicinum</i>	0.44 ± 0.03 ^b	0.2	0.6	100

Mean in the same column with different superscript differ significantly (P<0.05).

Gonadosomatic Index of *Atyagabonensis* and *Macrobrachiumfelicinium*

There were significant differences between both the Gonadosomatic Index (GSI) of the two species. *Macrobrachiumfelicinium* showed higher GSI (0.58 ± 0.041) than *Atyagabonensis* (0.33 ± 0.009)

Table 7: Gonadosomatic Index of *A. gabonensis* and *M. felicinum*

Species	Mean	Minimum	Maximum
<i>Atyagabonensis</i>	0.33 ± 0.009^b	0.06	0.97
<i>Macrobrachiumfelicinium</i>	0.58 ± 0.041^a	0.03	2.46

Mean in the same column with different superscript differ significantly ($P < 0.05$).

Discussion

Atya gabonensis males appear to be more in number than females, while *M. felicinum* has more females than males. Ukagwu and Deekae (2016) reported similar observation of more females *M. felicinum* than males with the sex ratio of 1:2 (M: F) in Akor River, Ibere, Ikwuano, Abia State. Similarly, a sex ratio of 1:2 (M: F) was established in *M. vollenhovenii* by Ukagwu and Deekae (2016) and also by George and Rao (1967) in respect of *Penaeus indicus*, *Metapenaeus dobsoni*, *Macrobrachium affinis* and *Parapenaeo psisstylifera*. These observations contradict the reports of (Menon, 1957 and Marioghae, 1982) in which the sex ratio was the same. In this study area, it is likely that more females of *M. felicinum* are prone or vulnerable to catch in nature than the males which migrate into deeper waters soon after spawning. According to Tawari-Fufeyin *et al.* (2005), sex ratios may not always be static, as they vary from season to season or from year to year within the same population.

Fecundity ranged from 230 to 69,782 and 230 to 69,782 for *A. gabonensis* and *M. felicinum* respectively. *Macrobrachium felicinum* is clearly found to be more fecund than *A. gabonensis*. Fecundity of *A. gabonensis* higher than that reported by Obande (2006) (950-27,700). That of *M. felicinum* was lower than that observed by New and Singholka (1982) (100,000 - 700, 000); and within the range reported by Rao (1998) (20,000 and 70,000) for *M. rosebergii*. Ribeiro *et al.* 2012 reported about 7,200 per clutch for *M. amazonicum*. The result of fecundity of both species in this study is higher than that recorded for other members of the genus *macrobrachium* by Coelho *et al.* (1982); Ovie, (1986); Marioghae, (1987); Ribeiro *et al.* (2012). The Fecundity/total length relationships show an increase in number of eggs with increasing female size; a similar situation was also observed by Albertoni *et al.* (2002) in *M. acanthurus*, Hart *et al.* (2003) in *M. felicinum* and Abowei (2010) in *M. macrobrachion*. The increase of fecundity with body size seems to be a rule that is applicable to many crustaceans (Udo and Ekpe, 1991; Llodra *et al.* 2000). *Atya gabonensis* had larger eggs than *M. felicinum*. Egg size has been shown to be an accurate measure of energetic investment both within and between caridean species (Llodra *et al.* 2000). Large eggs in several invertebrate groups have been shown to produce larger, more competent larvae (Llodra *et al.* 2000). Mashiko (1985) showed larger *Palaemon paucidens* eggs hatched into larger larvae, which survived longer and developed further under starvation conditions than smaller larvae. Thus, large eggs are likely to be more successful when food resources are limiting for larvae. The higher value of GSI of *M. felicinum* indicates more reproductive output than *A. gabonensis* in Makurdi.

Conclusion

Both species, *A. gabonensis* and *M. felicinum* are recommended as good candidates for aquaculture as their seeds are readily available in the Lower River Benue. *Macrobrachiumfelicinium* is suggested to have more reproductive output than *A. gabonensis*.

References

- Albertoni, E., Palma-Silva, C. and Esteves, F. (2002). Fecundity of *Macrobrachiumacanthurus* Eiegmann, 1836 (*Decapoda: Palaemonidae*) in a Tropical Coastal Lagoon Subjected to Human Impacts (Mace, Brazil). *Acta Limnologica Braziliensia*, 14(1): 71-80.
- Adite, A., Abou, Y., Sossoukpe, E., Gbaguidi, M.H.A.G. and Fiogbé, E.D. (2013). Meristic and Morphological Characterization of the Freshwater Prawn, *Macrobrachiummacrobrachion* (Herklots, 1851) from the Mono River-Coastal Lagoon System, Southern Benin (West Africa): Implications for Species Conservation. *International Journal of Biodiversity and Conservation*, 5(11): 704-714. doi: 10.5897/IJBC2013.0622.
- Anetekhai, M.A. (1986). Aspects of the bioecology of the African River prawn (*Macrobrachiumvollenhovenii*) in Asejire Lake, Ph.D. Thesis submitted to University of Ibadan, pp. 225.

- Anetekhai, M.A. (1990). Sexual Dimorphism and Egg Production in Africa River Prawn *Macrobrachiumvollenhovenii* from Asejire Lake, Oyo State, Nigeria. *Nigerian Journal of Science*, 24: 147-151.
- Coelho, P. A., Ramos-Porto, M., Barreto, A. V. and Costa, V. E. (1982b). Crescimentoeenviveiro de cultivo do camarãocanela*Macrobrachiumamazonicum* (Decapoda, Palaemonidae). *RevistaBrasileira de Zoologia*. 1(1): 45-49.
- Da Silva, R. R., Sampaio, C. M. S. and Santos, J. A. (2004). Fecundity and Fertility Of*MacrobrachiumAmazonicum* (Crustacea, Palaemonidae). *Brazilian Journal of Biology*, 64(3A): 489-500.
- Deekae S.N., J.F. Abowei. (2010). The Fecundity of *Macrobrachiummacrobrachion* (Herklots, 1851) from Luubara Creek, Ogoni Land, Niger Delta, Nigeria. *International Journal of Animal and Veterinary Advances*, 2(4): 148–154.
- Hart, A.I., Ansa E. J. and Sekibo, I. (2003). Sex Ratio, Sexual Dimorphism and Fecundity in Pond Reared Niger River Prawn, *Macrobrachiumfelicinurn* (Ilolthuis, 1949). *The Zoologist*, 2(1): 56-61.
- FAO (2008) Fishstat Plus (v. 2.32) issued 11.03.2008. FAO, Rome
- Fernandez–Palacios, H.Q., Robaina, M.L. and Valencia, A. (1998). Combined Effect of Dietry a–tocopherol and n–3 HUFA on Eggs Equality of Gilthead Sea Bream Brood Stock (*Sparus aurata*). *Aquaculture*, 161:475–476.
- George, M. J. and Rao, P. V. (1967). Distribution of Sex Ratio's of Penaeid Prawns in the Trawl Fishery off Cochin. Proceedings on Symposium on Crustacea. *Journal of Marine Biology Association India*, 11: 698– 700.
- Llodra, E.R., P.A., Tyler, J.T. Copley. (2000). Reproductive biology of three caridean shrimp, *Rimicarisexoculata*, *Chorocarischacei* and *Mirocaris fortunate* (Caridea: Decapoda), from Hydrothermal vents. *Journal of Marine Biological Association UK*, 80: 473–484.
- Marioghae, I.E. (1982). Notes on the biology and distribution of *M. vollenhovenii*, *M. macrobrachion* in the Lagos Lagoon. *Revue de ZoologieAfricaines*, 96(3): 493 - 508.
- Marioghae, I.E. (1987). An appraisal of the cultivability of Nigerian palaemonid prawns. ARAC/87/WP/4. UNDP/FAO/NIOMR Lagos. Working Paper, pp: 12.
- Menon, M.K.(1957). Contribution on the biology of penaeid prawn of the south west coast of India. Sex ratio and movements. *Indian Journal of Fish*, 4 (1): 62–74.
- New, M. B. and Singholka, S. (1982). Freshwater prawn farming: Manual for the culture of *Macrobrachiumrosenbergii*. FAO- Fisheries Technical Paper No., 225, 1982, 116.
- Obaje, N. G. (2009). Geology and Mineral Resources of Nigeria, London: Springer Dordrecht Heidelberg, Pp5-14.
- Obande, R. A. (2006). The biology of *Atya gabonensis* from Lower River Benue. Ph.D. Thesis, University of Lagos, Lagos. 70pp.

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Seasonal Variation in Compositions and Abundance of Fish Species In Asejire Lake, Oyo State

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Abstract

The research examined the composition and abundance of fish species in Asejire Lake, Oyo State, Nigeria. It was carried out between September 2018 and August 2019. Sampling of fish was carried out fortnightly and monofilament gill net was set at different locations to get a representative catch in the reservoir. Experimental gill nets of different mesh sizes ranging from 44.45 to 169.33 mm (1-3 fingers) were set at different location within the main dam. Fish samples were identified up to species level using a combination of identification guides by different authors. Thirty two species belonging to thirteen (13) families were identified with Bagrids and Cichlids as the most abundant. Family Bagrids represented 37.87% of the total number of fish caught, prominent within the family was *Chrysichthys nigrodigitatus* which constituted (62.13%) of the Bagrids in the sample and the least was *Bagrus bayad* which constituted (0.94%) of the Bagrids. The study showed more abundant fish in rainy season than dry season with total of five hundred and seven (507) out of eight hundred and fifty (850) individual fishes. Also, the number of species and family also varied with season, while 9 families were recorded in dry season, 12 families were recorded in the rainy season. Overall, the water body can be said to have good fish species diversity irrespective of the season.

Keywords: Asejire Lake, fish species, *Chrysichthys nigrodigitatus*, *Bagrus bayad*

Introduction

Fish community is an assemblage of fish species populations that occur together in the same place at the same time (Pyron, 2010). It has properties determined by the interactions among individual such as competition and parasitism. Fish community can also be viewed from the broader perspective in terms of species diversity, food-web, energy flow and interactions among guilds of species. It is the biological part of an ecosystem, as distinct from its physical environment. Fish community has complex properties arising from the interaction between species, competition, parasitism, predation and mutualism occurring among individuals appears to lie behind many patterns in community organization. Early this century the community was perceived as a 'super organism' whose number of species were somehow bound together such the community was born, lived, died and evolved as a whole. This view has been largely rejected in favor of the 'individualistic' concept which focuses on the community as a collection of individual species where community patterns can be explained by processes at the level of the individual (MacArthur, 1972).

Species diversity within a natural community is in a part of reflection of the diversity in the physical environment (Olaosebikan and Raji 2013). Natural diversity of most aquatic systems has witnessed various changes in stock diversity and abundance, resulting from structural changes in habitat, food composition and uncontrolled exploitation (Ita, 1982). The greater the variation in the physical environment, the more numerous is the species since there are more numerous microhabitats available and more niches to fill.

A community of fish can be characterized by its diversity which is a function of the number of different fish species it contains and their abundance. Diversity depends on species richness (the number of species) and on the evenness or equability of species abundant. Two hypothetical communities comprising the same species can differ greatly in structure and in their diversity, depending on their relative abundance distribution (Brander, 2009). Communities in which the fish species are all more or less equal in abundance exhibit evenness, whereas communities with one or a few abundant fish species and many rare ones show dominance (MacKenzie and Boyce, 2001). Also, community structure is related not only to the biological, but also to the physical structure of a community. One of the fundamental aims of community structure is to determine what factors and respective roles influence the structure of natural communities. Consequently, several studies have examined the effects of substratum variables on fish

community structure (Rajasuriya *et al.*, 1998). This study aims at evaluating the community structure of fish species in Asejire Lake.

Materials and Methods

Description of Study Area

Asejire Dam is 525 hectares (ha) man-made lake, constructed by impoundment of river Osun in 1970 on longitude 7.37°N and 4.13° E of the equator. The main source of water is river Osun which is flowing from the North to the South and lies about 25 km to the East of Ibadan. There are two other Dams (Ede and Eko-Ede) upstream Asejire dam whose opening and closure consequently affect its water level (Ipinmoroti, 2013).

Sampling stratification and Identification

The lake was partitioned into three different locations. Sampling of fish was carried out fortnightly and gill net was set at different locations to get a representative catch on the main dam. Experimental gill nets of different mesh sizes ranging from 44.45 to 169.33mm (1-3 fingers) were set at different location within the main dam. Fish samples were identified up to species level using a combination of identification guides by different authors, FishBase (2019), Olaosebikan and Raji, (2013) and Idodo-Umeh (2003). From the data collected, the relative abundance of the fish species, their families and total seasonal and monthly catches were determined.

Statistical Analysis

The data was presented with descriptive statistics using Microsoft Excel 2013 package.

Result and Discussion

Composition of Fish Species

Thirty two species belonging to thirteen (13) families were identified. From this study Bagrids and Cichlids were the most abundant. Ipinmoroti (2013) however identified twenty seven (27) species. Ipinmoroti *et al.* (2018) identified nineteen (19) species. Dry season in south West Nigeria, is a period characterized by poor water quality, reduced water level, high temperature and salinity (Lawson and Olusanya, 2010), under these condition, migration of fish species may be responsible for low catch recorded during these period. The species were either susceptible to the gears used or have disappeared (Ipinmoroti, 2013). The disappearance of fish in Lake Victoria were attributed to open access nature of the fisheries, unregulated fishing efforts coupled with the use of small mesh gears by fishermen who were desperate to increase their catch and the introduction of alien species (Ogutu-Ohwayo, 2005). All above cited work are also applicable to the fisheries of Asejire Lake.

Fish species composition of this study comprises of 32 individuals from 13 families and 32 species as shown in (Table 1 and 2). This composition indicated the presence of freshwater fish species. The representation included Cyprinidae which was represented by *Barbus lagoensis* and *Labeo parvus*, Schilbeidae by *Schilbe senegallus* and *Schilbe mystus*. Clariidae by *Clarias gariepinus*, *Clarias macromystax* and *Heterobranchus longifilis*. Mochokidae by *Synodontis budgetti* and *Synodontis melanoptera*. Cichlidae by *Coptodon guineensis*, *Coptodon mariae*, *Coptodon zilli*, *Hemichromis fasciatus*, *Oreochromis aureus*, *Oreochromis niloticus*, *Sarotherodon galilaeus*, *Sarotherodon melanotheron* and *Red tilapia*. Mormyridae by *Mormyrops anguilloides* and *Mormyrops caballus*. Characidae by *Hydrocynus forskahlii*, *Brycinus nurse* and *Alestes chaperi*. Bagridae by *Bagrus bayad*, *Chrysichthys auratus* and *Chrysichthys nigrodigitatus*. Citharinidae by *Citharinus citharus*. Hepsetidae by *Hepsetus odoe*. Polypteridae by *Polypterus bichir bichir*. Channidae by *Parachanna obscura*. Centropomidae by *Lates niloticus*.

Relative Abundance of fish species

The most diverse group was the Cichlids family with nine (9) different species i.e. *Coptodon guineensis*, *Coptodon mariae*, *Coptodon zilli*, *Hemichromis fasciatus*, *Oreochromis aureus*, *Oreochromis niloticus*, *Sarotherodon galilaeus*, *Sarotherodon melanotheron* and *Red tilapia*, prominent within this family was *Oreochromis niloticus* which constituted (15.76%) out of (35.52%) of the Cichlids family. Family Bagrids represented (37.87%) of the total number of fish caught. Prominent within the family was *Chrysichthys nigrodigitatus* which constituted (62.13%) of the Bagrids in the sample and the least of the species was *Bagrus bayad* which constituted (0.94%) of the Bagrids. Followed by Characidae with (13.7%), Schilbeidae with (4.00%), Cyprinidae with (2.88%), Mochokidae with (2.24%), Mormyridae with (1.65%), Hepsetidae with (1.53%). Other least in abundance were

Centropomidae, Citharinidae (0.35%), Polypteridae and Channidae respectively, having the least abundance comprising of 1 individual (0.23%). (Table 2).

Table 1: Composition and abundance of fish species caught during dry season

	November	December	January	February	March	TOTAL	AR
CENTROPOMIDAE							
<i>Lates niloticus</i>	0	0	0	2	1	3	0.87
SCHILBEIDAE							
<i>Schilbe mystus</i>	1	8	0	0	0	9	2.62
<i>Schilbe senegallus</i>	0	1	0	0	0	1	0.29
<i>Schilbe uranoscopus</i>	0	1	0	0	0	1	0.29
CLARIIDAE							
<i>Clarias gariepinus</i>	2	0	0	0	0	2	0.58
<i>Clarias macromystax</i>	1	0	0	0	0	1	0.29
<i>Heterobranchus longifilis</i>	0	0	0	0	1	1	0.29
MOCHOKIDAE							
<i>Synodontis budgetti</i>	4	5	2	0	0	11	3.21
CICHLIDAE							
<i>Coptodon zilli</i>	1	0	0	17	0	18	5.25
<i>Coptodon guineensis</i>	0	0	0	0	15	15	4.37
<i>Coptodon marie</i>	0	0	0	0	7	7	2.04
<i>Oreochromis niloticus</i>	1	10	3	2	8	24	6.99
<i>Sarotherodon galilaeus</i>	7	0	0	0	0	7	2.04
<i>Red tilapia</i>	7	4	0	7	0	18	5.23
<i>Sarotherodon melanotheron</i>	0	3	0	0	0	3	0.87
MORMYRIDAE							
<i>Mormyrops anguilloides</i>	0	1	1	0	0	2	0.58
<i>Mormyrops caballus</i>	0	0	1	0	0	1	0.29
CHARACIDAE							
<i>Hydrocynus forskahlii</i>	0	4	0	8	9	21	6.12
<i>Brycinus nurse</i>	0	0	10	13	2	25	7.29
HEPSETIDAE							
<i>Hepsetus ode</i>	0	0	0	0	3	3	0.87
BAGRIDAE							
<i>Chrysichthys auratus</i>	8	18	0	12	0	38	11.08
<i>Chrysichthys nigrodigitatus</i>	11	39	7	62	13	132	38.48
TOTAL	43	94	24	123	59	343	100

Table 2: Composition and abundance of fish species caught during rainy season

Species	Apr	May	Jun	Jul	Sep	Oct	Total	Relative Abundance
CYPRINIDAE	9	1	0	0	5	1	16	3.16
<i>Labeo parvus</i>	9	1	0	0	5	0	15	2.96
<i>Barbus lagoensis</i>	0	0	0	0	0	1	1	0.2
SCHILBEIDAE	8	3	2	1	0	9	23	4.54
<i>Schilbe mystus</i>	8	3	2	1	0	1	15	2.96
<i>Schilbe senegallus</i>	0	0	0	0	0	8	8	1.58
CLARIIDAE	0	0	0	0	3	1	3	0.79
<i>Clarias gariepinus</i>	0	0	0	0	2	1	3	0.59
<i>Clarias macromystax</i>	0	0	0	0	1	0	1	0.2
MOCHOKIDAE	0	0	0	0	7	1	8	1.58
<i>Synodontis budgetti</i>	0	0	0	0	7	0	7	1.38
<i>Synodontis melanoptera</i>	0	0	0	0	0	1	1	0.2
CHANNIDAE	2	0	0	0	0	0	2	0.39
<i>Parachanna obscura</i>	2	0	0	0	0	0	2	0.39
CICHLIDAE	35	42	54	31	31	13	210	41.23
<i>Hemichromis fasciatus</i>	0	1	0	0	0	1	2	0.39
<i>Coptodon zilli</i>	8	9	3	20	0	3	43	8.48
<i>Coptodon guineensis</i>	4	0	0	0	19	0	23	4.54
<i>Coptodon marie</i>	0	7	1	0	0	0	8	1.58
<i>Oreochromis niloticus</i>	24	22	50	4	1	9	110	21.7
<i>Oreochromis aureus</i>	1	3	0	7	0	0	11	2.17
<i>Sarotherodon galilaeus</i>	2	0	0	0	1	0	3	0.59
<i>Red tilapia</i>	0	0	0	0	8	0	8	1.58
<i>Sarotherodon melanothron</i>	0	0	0	0	2	0	2	0.2
POLYPTERIDAE	2	0	0	0	0	0	2	0.2
<i>Polypterus bichir</i>	2	0	0	0	0	0	2	0.2
MORMYRIDAE	1	0	0	2	5	3	11	2.17
<i>Mormyrops anguilloides</i>	1	0	0	2	5	3	11	2.17
CHARACIDAE	5	35	19	3	1	0	66	13.01
<i>Hydrocynus forskahlii</i>	4	6	7	2	1	0	20	3.94
<i>Brycinus nurse</i>	1	29	12	1	0	0	43	8.48
<i>Alestes chaperi</i>	0	0	0	0	0	0	3	0.59
HEPSETIDAE	1	1	8	0	0	0	10	1.97
<i>Hepsetus ode</i>	1	1	8	0	0	0	10	1.97
CITHARINIDAE	2	0	0	1	0	0	3	0.59
<i>Citharinus citharus</i>	2	0	0	1	0	0	3	0.59
BAGRIDAE	19	66	14	9	15	29	152	29.98
<i>Bagrus bayad</i>	0	0	5	3	0	0	8	1.58
<i>Chrysichthys auratus</i>	4	0	0	0	15	0	19	3.75
<i>Chrysichthys nigrodigitatus</i>	15	66	9	6	0	29	125	24.65
TOTAL	88	148	100	47	67	57	507	100

Conclusion

It was recorded from this study that fish were abundant in rainy season than dry season with total fish caught of five hundred and seven (507) out of eight hundred and fifty (850) individual species. The cages in Asejire Lake has caused some fishes to be rarely caught, because some of this species find themselves into the cages at young age (juvenile) and it is difficult to come out as they have increase in size and weight due to the feed given. Some are under the cages and around whereas the fishermen are not allowed to fish close to the cages. The species diversity generally showed a healthy lake.

References

- Brander, K.M. (2009). Impacts of climate change on marine ecosystems and fisheries. *J. Mar Biol. Ass. India* 51(1):1-13.
- Enim, U.I. (2012). What Concerns Nigerian Fisherfolks with Climate? Current Issues in Sustainable Tropical Agriculture. Faculty of Agriculture, University of Uyo, Nigeria, 1:1-13.
- FishBase 2019: Fish identification guide. <https://www.fishbase.se>
- Idodo-Umeh, G. (2003). Freshwater Fishes of Nigeria (Taxonomy, Ecological Notes Diet and utilization) Idodo-Umeh Publishers Ltd.
- Ipinmoroti, M.O. (2013). Ichthyofauna diversity of Lake Asejire: ecological implication. *Int J Fish Aquac.*;5(10).
- Ipinmoroti, M.O. Iyiola, A.O., Akanmu, O.A., Orisasona, O. and Fawole, N. (2018) In: A. Kallel et al. (eds.), Recent Advances in Environmental Science from the Euro-Mediterranean and Surrounding Regions, Advances in Science, Technology & Innovation, https://doi.org/10.1007/978-3-319-70548-4_422
- Ita, E.O. (1982) Biological indices of overfishing in Kainji Lake and the management proposal for the lake fishery. *Kainji Lake Research Institute Technical Report Series*, No.8, KLRI, New Bussa, 31p.
- Lawson, E.O. and Olusanya O.M. (2010). Fish diversity in three tributaries of River Ore South west, Nigeria. *World Journal of Fish and Marine Sciences*, 2(6): 524-531.
- MacArthur, R. H. (1972). *Geographical ecology. Patterns in the distribution of species*. Harper and Row, New York.
- MacKenzie, D. I., and M. S. Boyce. (2001). Estimating closed population size using negative binomial models. *Western Black Bear Workshop* 7:21-23
- Ogutu-Ohwayo, R. (2005) Management of the Nile perch, *Lates niloticus* fishery in Lake Victoria in light of the changes in its life history characteristics. *African Journal of Ecology* 42(4), 306-314
- Olaosebikan, B. and Raji, A. (2013) Field guide to Nigerian Freshwater Fishes. Federal College of Freshwater Fisheries, New Bussa, Niger State, Nigeria.
- Pyron, M. (2010) Characterizing Communities. *Nature Education Knowledge* 3(10):39
- Rajasuriya, A., Oehman, M. C. and Johnstone, R. W. (1998). Coral and sandstone reef habitats in north-western Sri Lanka: Pattern in the distribution of coral communities. *Hydrobiologia* 362, 31-43.

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Male Gonad Anatomy and Spermatozoa Count Of *Chrysichthys nigrodigitatus*

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Abstract

The Anatomy and spermatozoa count of *Chrysichthys nigrodigitatus* was carried out between November 2020 and April 2021 at Badore Fish Farm of the Institute, with the aim of identifying the position, structure of the male gonad and quantity of their spermatozoa. The identified gonad featured, mass lobes fused together that extended to the genital opening. The milt was colorless, when in contact with water it turned to cream color. The spermatozoa count per ml was within the range of 65.8×10^6 to 69.3×10^6 . The outcome of this project will encourage more work on artificial induced propagation of *Chrysichthys nigrodigitatus*.

Key Words: Male gonad, Anatomy, spermatozoa count, *Chrysichthys nigrodigitatus*

Introduction

The silver catfish *Chrysichthys nigrodigitatus* is an African species belongs to the genus *Chrysichthys*. It is a commercially important fish species (Evelyn Ragheb, 2016) that has found its way into the International market thus making it a source of foreign exchange earnings in Nigeria (Daniel, and Edak, 2020). Though widespread in the natural inland waters where species grow and spawns actively. It is quite difficult to breed in captivity hindering the supply of seeds for aquaculture purpose, (Houechanous *et al.*, 2020). Gonadosomatic index (GSI), egg size and spermatozoa count have been useful in sexual maturity, survival studies and aquaculture based induced spawning and egg incubation (Coates, 1988). Several works have been done on GSI and egg size of different fish species from Nigeria waters and these include Anene and Okorie (2008); Fawole and Arawomo (2009). However, little work has been done on GSI and egg size but none on spermatozoa count of *Chrysichthys nigrodigitatus*. The aim of this study is to determine the Male Gonad Anatomy and Spermatozoa count of *Chrysichthys nigrodigitatus*.

Materials And Method

Samples of *Chrysichthys nigrodigitatus* males used for the study were obtained by fishermen using PVC pipes set to trap matured males brood-stock between the month of November and April 2021, at Lagos lagoon, Epe axis water front Longitude $3^{\circ}59'E$ and Latitude $6^{\circ}35'N$. They were transported in oxygen bags to the Badore Experimental Research Laboratory of Nigerian Institute for Oceanography and Marine Research. The Weight (g), Total and Standard Lengths (cm) respectively were measured and recorded.

Spermatozoa Count

The extracted gonads were dissected and the milt serially diluted with fixation (3% saline water) as shown in table 3. The serially diluted milt was arranged in a test tube rack for examination. Sample suspension was pipetted on a glass slide and images were observed and captured. The morphology of the male gonad is like a mass of lobes fused together unlike *Clarias* and *Heterobranchius* with two distinct separated lobes with serration.

Magnification = The Optical image magnification x Charge-Coupled Device (CCD).

Magnification = $40 \times 0.9 = 36$

The concentration of milt was determined by counting cells with 0.1mm depth (Haemocytometer-American optical corporation, NY, USA). The sample suspension were mixed by tapping the tube for uniform distribution and then loaded through the 2 angle v side of the haemocytometer placed under the microscope for milt cell count. The slide was allowed to settle for 10 minutes before observation under the microscope. Five (5) cells from the big counter (25) were counted with dark field Olympus microscope equipped with a computer system. The milt concentration was calculated as:

Conc. /ml = average cell count x dilution factor x 10,000 μm . Expressed as $\times 10^6$

Results

The morphological features of *C. nigrodigitatus* is shown in Plate 1 to 3. The results of the morphometric measurement of matured male Broodstock of *C. nigrodigitatus* used for the experiment are presented in Table 1. The weight of the sampled fish ranged between 358 to 592g. The fish with the highest weight of 592g has the highest weight (90g) of right and left lobes and the highest (8339) number of eggs. The Gonadosomatic Index (GSI) ranged between 15.00 and 20.39. The milt concentrations of male *C. nigrodigitatus* from Epe axis of Lagos Lagoon are presented in Table 3. The results obtained indicated that the milt concentrations ranged between 65.8×10^6 and 103.8×10^6 . While, the sperm cell count (Table 4) ranged between 102.8 and 135.8.

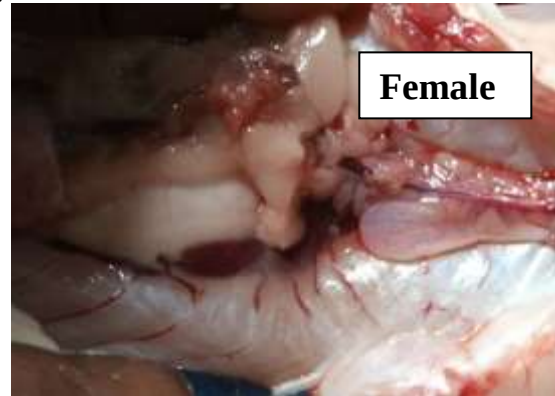


Plate 1: Ventral view of male and female of *C. nigrodigitatus*.

Plate 2: Dissection showing Gonad of Male *C. nigrodigitatus*



Plate 3A: Extracted Male gonad of *C. nigrodigitatus*. Plate 3B: Schematic Diagram of Male Gonad of *C. nigrodigitatus*.

Table1: Morphometric measurement of matured male Broodstock of *C. nigrodigitatus* used for the experiment.

Specimen(fish)	Weight of fish(g)	Standard length(cm)	Total length(cm)	Weight of the lobe(g)
1	370	25.0	31.8	1.75
2	270	24.0	30.6	1.30
3	300	26.2	32.3	1.50
4	317	26.0	33.0	1.20
5	261	24.2	30.2	1.40

Table 2: Determination of milt concentration and assessment

Specimen(fish)	Dilution factor	Stock-Milt Vol. (ml)	Diluents	Conc./ml
1	51	0.2	10ml(10,000µm)	68.8x10 ⁶
2	51	0.2	10ml(10,000µm)	65.8x10 ⁶
3	51	0.2	10ml(10,000µm)	67.310 ⁶
4	51	0.2	10ml(10,000µm)	69.310 ⁶
5	51	0.2	10ml(10,000µm)	66.310 ⁶

Table 3: Sperm cell count using Haemocytometer

Specimen	1	2	3	4	5	Total	Mean
1	76	85	141	123	89	514	102.8 ± 27.8
2	96	104	188	142	115	645	129 ± 37.3
3	94	102	161	139	125	621	124.2±27.3
4	113	108	131	132	143	627	125.414.5
5	66	101	167	136	104	570	114±40.2

Discussion

This work was carried out to determine the feasibility of breeding *Chrysichthys nigrodigitatus* artificially, in order to boost or bridge the gap of fish demand deficit. Previously, identification of male gonad of *C.nigrodigitatus* has been difficult but there is breakthrough of proper identification in this study which will enhance artificial breeding of *C.nigrodigitatus*. Although, there is dearth of information on artificial breeding of *C.nigrodigitatus*. It has been difficult to breed using artificial induced method; this could be as a result of the inability to identify the location of the male gonad within the body cavity. Spermatozoa count is the quantity of spermatozoa which is used to determine the viability and maturity of the male. The higher the number of the sperm cells, the better the spermatozoa. The above result of $67.5 \times 10^6 \pm 1.5$ obtained from this study is lower than $2.6 - 3.5 \times 10^{10}$ obtained by Solomon *et al*, (2015) for cultured Clarias and 5.96×10^{10} , 6.54×10^{10} and 16.48×10^{10} reported by Okoye *et al*, (2017) for Clarias cultured for 6months, 9months and 12months respectively. The disparities could be from the differences in the fish used, environment where the fish were harvested from and their sizes.

The composition of fish semen and its physical characteristics have been found to vary with the fish species (Oboh and omoigberale, 2013). Milt quality is a measure of the ability of the sperm cells to successfully fertilise an egg and such ability mostly depends on qualitative parameters of milt such as composition of seminal fluid, milt volume, sperm density and sperm motility (Paugy *et al.*, 2003). The semen quality also varies considerably among the individuals of the same species (Onah, 2013). In this study, the milt concentrations of and sperm cell count male *C. nigrodigitatus* from Epe axis of Lagos Lagoon ranged between 65.8×10^6 and 103.8×10^6 and 102.8 and 135.8 respectively. The reports were in line with the findings of Ikpi and Okey (2010). These ranges are within acceptable sperm quality for successful fish reproduction (Billard and Cosson, 1992).

Conclusion

The breakthrough in this project will encourage more research on artificial induced breeding of *Chrysichthysnigrodigitatus*.

References

- Adilije, C. M., Uyoh, E. A., Ntui, V. O. and Ama-Abasi, D. (2020). Morphological and Genetic Diversity Studies of *Chrysichthysnigrodigitatus* from the Cross River, Nigeria, Using Microsatellite Markers. *Annual Research & Review in Biology* 35(5): 42-52.
- Anene, A. and Okorie, P.U. (2008). Some aspects of the reproductive biology of *Tilapia mariae* (Boulenger, 1901) in a small lake in southeastern Nigeria. *African Journal of Biotechnology* 7(14):2478 – 2482.
- Billard R, and Cosson M.P (1992). Some problems related to the assessment of sperm motility in freshwater fish. *J. Exp. Zool.* 261:122-131.
- Coates, D. (1988). Length-dependent changes in egg size, and fecundity in females, and brooded embryo size in males of fork tailed catfishes (Pisces: Ariidae) from the Sepik River, Papua, New Guinea, with some implications for stock assessments. *Journal of Fish Biology* 33: 455-464.

- Evelyn R. (2016). "Reproductive biology of catfish *Chrysichthys auratus*, Geoffroy Saint-Hilaire, 1809, (Family: bagridae) from Damietta branch of the river Nile, Egypt," *The Egyptian Journal of Aquatic Research* **42**(3): 349–356.
- Fawole, O.O and Arawomo, G.A.O. (2009). Fecundity of *Sarotherodon galilaeus* (Pisces: Cichlidae) in the Opa Reservoir, Ile-Ife, Nigeria. *Revista de Biologia Tropical*, 48(1): 1-6.
- Ikpi and Okey (2010). Estimation of Dietary Composition and Fecundity of African Carp, Labeo Coubie, Cross River, Nigeria. *J. Appl. Sci. Environ. Manage.* 14 (4) 19 – 24.
- Oboh I. P and Omoigberale M.O (2013). Fecundity and spawning frequency of *Chrysichthys furcatus* Gunther, 1864 (Osteichthyes: Bagridae) from Jamieson River, Nigeria. *Peak J. Agric. Sci.* 2(2), 21- 29.
- Okoye, C.N., Dan, J., Susan, O., Eze, U., Udomah, A.F., Ugwu, O.H. and Ozokoye, A.C. (2017). Semen Quality Parameters Of Cultured Broodstock African Catfish (*Clarias gariepinus*) of different Ages. *Animal Research International* **14**(3): 2777 – 2784.
- Onah, G (2013). Aspect of the biology of *Mormyrus rume* of Cross river as Ahaha. B.Sc. project, Cross River University of Technology
- Paugy, D., Leveque, C. and Teugels, G.G. (2003). The Fresh and Brackish water Fishes of West Africa, Volume I, Institute of Research and Development Editions. Collection Fauneet Floretropicales 40, Paris. 457p.
- Solomon, S. G., Ataguba, G. A., Okomova, V. T. and Solomon, P. (2015). Relationship between somatic, gonadal characteristics and semen quality in the male African catfish *Clarias gariepinus* broodstock. *International Journal of Aquaculture* **5**(29): 1 – 5.

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Assessment of Water Quality Parameters of Otamiri River around the Cage Culture Site**Adaka, G. S., Isong, A. E., Anyanwu, C. N., Osuigwe, D. I. and Uzoma, J. I.**

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Corresponding author: revadaka@gmail.com; +2348037838049**Abstract**

This research evaluates water quality parameters around the cage culture in the Otamiri River around the cage culture site. A total of 14 physico-chemical parameters of water were determined using APHA method. Water samples were collected and analyzed in the laboratory to ascertain the level of the concentration of the parameters being monitored. The result of the mean concentration of the parameters are pH (6.04), temperature (26.26°C), conductivity (26.80µs/cm), turbidity (5.15 NTU), TSS (3.90mg/l), TDS (13.80mg/l), Nitrate (0.30mg/l), Sulphate (10.10mg/l) Phosphate (1.13mg/l), Total Hardness (40.90mg/l), Ammonia Nitrogen (0.43mg/l), DO (5.3mg/l), Alkalinity (46.9mg/l). The physico-chemical parameters analyzed did not exceed the water quality standard by WHO, suggesting that the river is relatively unpolluted. The study showed variation in water quality parameters along the course of the River, reflecting human activities.

Key words: Parameters, Hardness, Cage, Concentrations

Introduction

Water is one of the most important and precious natural resources. Without it, there would be no life on earth. Water is the culture environment for fish and other aquatic organisms. It is the physical support by which they carry out their life function such as swimming, feeding, breeding, digestion and excretion (Bronmark and Hanssan, 2005). In the culture of fish, water quality is very critical for the growth, survival and the production of fish and other aquatic organisms. Water quality is a term used to describe the condition or environmental health of a water body or a resource. It is the standard of purity that is necessary for the protection of finfish, shellfish, and other aquatic population in the aquatic environment (Diersing, 2009).

A pond with good water quality will produce more and healthier fish than a pond with poor quality water (Boyd, 1998). Thus, it is no surprise that professional fish culturists state that “water quality determines to a great extent the success or failure of a fish culture operation” (Piper *et al.*, 1982). Some of the physico-chemical parameters that are regularly measured in a pond include; Temperature, Dissolved Oxygen, Alkalinity, Hardness, pH, Turbidity and etc. Water qualities in ponds changes continuously and are affected by each other along with the physical and biological characteristics (USDA, 1996). Early identification of water quality degradation through routine maintenance permits aqua-culturist to implement minor operational changes to correct identified problems before it reaches an extreme condition. When degradation reaches extreme level, cultured organisms experience depressed growth rates, increase disease conditions and even death (Moyle, 1946). Thus, the optimum fish production can be achieved only when the water quality is effectively managed, therefore water used for the cultivation of fish cannot yield maximum production if the environmental conditions are not optimal for the growth of fish and other aquatic organism. Water quality is determined by the physical and chemical limnology of the water body and includes all physical, chemical and biological factors of water that influence the beneficial use of water (Mustapha, 2008). The study seeks to assess the water quality of the River and the test media (cage) to compare with national and international standard for aquatic life.

Material and Methods

The study was conducted within the stretch of Otamiri River that passes through Federal University for Technology Owerri. It is bounded by longitudes 6°58'E and 7°04'E and latitude 5°23'N and 5°30'N. The Otamiri river has an average depth of about 7ft (2.13m), a width range of 18-25 ft (5.488-7.621m), and channel ground elevation of about 125ft (38.109) within FUTO (Federal Ministry of Aviation, 2001). The river runs from Egbu where it has its major discharge source, and cuts through Nekede, Ihiagwa, Eziobodo, Olokwu-Umuso, Mgbirichi, Umuagwo, and finally to Ozuzu in Elche town of River state of Nigeria, where it finally joins the Atlantic Ocean. The river was the main source of water to aforementioned traversed communities for domestic use and other purpose in the past before introduction of water boreholes. The river also serves as major boundary between adjoining communities. The study

area is located within tropical rainforest belt of Nigeria. Over the years the original tropical rainforest has been cultivated and deforested and has largely been replaced by secondary forest. The study area experiences a mean annual temperature of 27°C and annual rainfall of 200-300cm with most of the rainfall in the rainy season from April to early November (Iloeje, 1979). Water samples were collected fortnightly from the Otamiri River at the Federal University of Technology, Owerri, Imo State, Nigeria where cage culture was carried out using *Microdis mispuerula* as feed substitute, the water samples were collected in plastic containers that have been properly washed, cleaned and allowed to dry. Samples were collected from three stations (Upstream A, Mid-Stream B & Down-Stream C) for six months.

The measurement of the various parameters was taken using a Lamotte test kit model AQ-2/AQ-3. The test kit is suitable for measuring the pH, Dissolved Oxygen, Alkalinity, Ammonia Nitrogen, Carbon dioxide, Chloride and Hardness. The kit can be used following two test methods measuring parameters and the titrimetric procedure which involves taking numeric readings to evaluate parameters. Simple correlation co-efficient (r) analysis between different parameters and the Analysis of Variance (ANOVA) were also employed for the statistical interpretation of data obtained from the study using MINITAB software.

Results

The Mean and Standard Deviation of Water Quality parameters in the Studied Locations of Otamiri river at Federal University of Technology, Owerri (FUTO) during the study period collected at three sampling points are presented in the Tables 1.

Table 1: Mean and Standard Deviation of Water Quality in the Studied Locations

Locations	Temp	pH	Conductivity	Turbidity	TSS	TDS	Nitrate	Sulphate	Phosphate	Total Hardness	Ammonium nitrate	DO	Alkalinity
Upstream A	26.29 ±0.54	6.01± 0.02	26.53±0 .98	5.28± 0.75	3.83± 0.15	14.10 ±0.08	0.30 ±0.08	11.20 ±0.08	1.00± 0	40.03 ±0.05	04.47± 0	6.55± 0.17	44.72 ±0.01
Mid-Stream B	26.25 ±0.5	6.09± 0.05	25.80±0 .22	5.63± 0.90	3.83± 0.17	13.08 ±0.10	0.40 ±0	10.60 ±0.41	1.20± 0	40.25 ±0.06	0.43±0 .04	5.27± 0.21	45.77 ±1.60
Down-Stream C	26.21 ±0.4	6.03± 0.04	25.73±1 .20	4.53± 0.37	3.95± 0.30	14.13 ±0.10	0.20 ±0	11.05 ±0.10	1.20± 0	42.55 ±0.10	04.47± 0	4.08± 0.05	48.99 ±0.33
LSD(0.05)	0.13(NS)	0.07(NS)	1.10(NS)	1.35	0.39(NS)	0.07(NS)	NS	0.39	NS	0.13	0.04(NS)	0.20	1.74

LSD = Least significant difference, NS= Not significant at 0.05 probability level

The pH range of the three stations in the Otamiri River was 6.01±0.02 to 6.09±0.05 which falls within the slightly acidic condition typically of tropical forest river. Turbidity was highest (5.63 NTU) at station B and least (4.53) at station C. Nitrate was highest (0.40g/l) at point B and least (0.20g/l) at point C. Concentration of means in sulphate was highest (11.20mg/l) at point A and least (10.60mg/l) at point B. The alkalinity values ranged between 44.72 ± 0.001mg/l and 48.99±0.33mg/l in this study.

Discussion

In this study, water temperature values ranged from 26.21±0.4 to 26.29±0.54, (Table 1). The temperature values are within the recommended limit by WHO (2003) which also agreed with the temperature value reported by Mustapha (2008) for Oyun reservoir, Akoma (2008) for Osse River and Adaka, *et al*, (2016) for Njaba river in Imo State. According to Akoma (2008), temperature variation in tropical water bodies are of minimal effect and also vary according to the seasons. The pH range of the three stations in the Otamiri River was 6.01±0.02 to 6.09±0.05 and falls within the slightly acidic condition typically of tropical rain forest river. These indicate acidity of water, which could be attributed to bacterial oxidation of organic matter, waste from drainage, etc. The acidity might also be due to the presence of carbon dioxide or mineral acids.

The relatively high value of alkalinity in this study agrees with the finding from many other water bodies in Nigeria; Adebisi (1981), recorded 77mg/l CaCO_3 for Ogun river, Ogbelibu and Victor (1995) recorded 120mg/l CaCO_3 for

Okomu forest reserve and Chindah, *et al.* (2006) also recorded a range of 50.7-14.7mg/l for Ntawogba stream, Port-Harcourt. Higher alkalinity values were obtained in point C in this study and could be comparing with Kadiri (2000) who had a similar report but at variance with the finding of Chindah, *et al.* (2006).

Higher total hardness in point C could be due to higher concentration of calcium and magnesium. The utilization of this ions by organisms must have caused the decrease in the concentration of the total hardness in points A and B. Hardness is classified into the following categories; 50-150mg/l for moderately hard; 150-300mg/l for hard; and 300mg/l and above, very hard (Mustapha 2008). The mean values for hardness the various points studied put the Otamiri River under soft water body (0-50 mg/l). Turbidity is the amount of transparency of a water body. Turbidity is affected by the amount of effluents being discharged into a water body and proportional to the amount of dissolve solids (Onuoha, *et al.* 2011). Turbidity was highest (5.63 NTU) at station B and least (4.53) at station C, at this concentration level, optical effect cannot distort the food chain of aquatic organisms by dispersion of particles which interferes with light ray passing through the water. Correlation analysis revealed that the quality in Otamiri River around the cage culture was influence by seasonal and environmental conditions. The strong positive correlation in the concentration between some parameters observed indicated that an increase in the concentration one parameter enhanced the concentration of the other. Negative correlation could also be accounted for by the dilution effect of the incoming water during the rainy season and the concentration due to evaporation of water during dry season.

Conclusion

Base on the findings, the Otamiri River need periodic sampling of the water quality to ascertain the level of pollution because of the serious human activities in the water and the levels of the different parameters analyzed in this study. Work should be done on the biological and microbial profile of the river during the dry and wet seasons in other to know the inherent dangers, if any. Meanwhile, the government should provide sanitary methods of waste disposal system which would limit the discharge of industrial effluents directly into the river. Pipe born water and bore holes should also be provided to the people of the area to reduce their dependence on the river water for drinking and other activities.

References

- Adaka, G. S., Olele, N. F., Ikenga, E. E. and Chris-Emenyonu, C. M. (2017). Analysis of the Physico-Chemical Parameters of Njaba River: An Effective Tool for Fishing Enterprise in Southeastern, Nigeria. *International Journal of Entrepreneurship and Development Studies*, (1) 1: 1-11.
- Adebisi, A.A (1981). The physicochemical properties and hydrology of a tropical seasonal river-Upper Ogun river *Hydrobiologia*, 79:157-165.
- Akoma, O. C. (2008). Phytoplankton and nutrient dynamics of tropical estuary system, in Imo River estuary, Nigeria. *African research review*. 2(2): 253-264.
- Boyd, C. E. (1998). Water quality for pond Aquaculture. Resource development series, 43:1-11
- Bronmark, C. and Hansson L. A. (2005). The biology of Lakes and Ponds. Oxford University press, Oxford. 285pp.
- Chindah, A. C., Braide, S. A., Obianefo, F. and Obunwo, C. C. 2006. Water quality and periphyton community of a stream system receiving municipal waste discharges in Rivers State, Niger Delta, Nigeria. *Estud. Biol.* 28(64):73-89.
- Diersing, N. (2009) "Water quality: frequently ask question", Florida brooks national Marine sanctuary, key west, Florida. 33pp
- Illoeje, N. P. (1979). A new geography of Nigeria. New revised edition. Longman Nigeria. 55pp
- Kadiri, M. O. (2000). Seasonal trend in the chemical limnology of a shallow Nigeria man-made Lake. *Actahydrobiol* 42:29-40.
- Mustapha, M. K. (2008). Assessment of the water quality of oyun reservoir, offa, Nigeria. Using selected physico-chemical parameters. *Turkish Journal of Fisheries and aquatic science*.8:309-319.
- Moyle, J.B (1946). Some indices of Lake Productivity. *Trans Armer. Fish. Soc.* 76:322-334.
- Ogbeibu, A. E. and Victor, R. (1995). Hydrobiological studies of water bodies in the Okomu Forest Reserve (Sanctuary) in Southern Nigeria. 2. Physical and chemical hydrobiology. *Tropical Freshwater Biology*. 4:83- 100.
- Onuoha, P.C., Nwankwo, D.I., Chukwu, L.O. and Wim, V. (2011): Spatiotemporal viariations in phytoplankton biomass and diversity in a tropical eutrophic lagoon, Nigeria. *Journal of American Science*. 7(8):33-46.
- Piper, R. G., I. B. McElwain, L. E. Orme, J. P. McCraren, L. G. Flower, and J. R. Leonard. 1982. Fish hatchery management. U. S. Fish and Wildlife Service, Washington, D. C.

- USDA (U.S. Department of Agriculture). (1996). Aquaculture outlook. U.S. Department of Agriculture, Economic Research Service, Washington, D.C. Report LDP-AQS-4, October 8, 1996.
- World Health Organization (WHO) (2003). Guidelines for safe recreational water environments. Volume 1: Coastal and Freshwaters, Geneva, pp1-33.

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Concentrations of Trace Metals in Five Freshwater Fish Species Caught In Majidun River, Ikorodu, Lagos State, Southwest Nigeria

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Abstract

This study assessed the levels and the accumulation of trace metals in the various organs of five freshwater fish species (*Sarotherodon melanotheron*, *Protopterus annectens*, *Parachanna obscura*, *Pantherodon buchholzi*, and *Eleotris picta*) caught in Majidun river and to determine the toxicity and relationship between the collected samples and the trace metals detected in the samples. Atomic absorption spectrophotometer (AAS) was used to evaluate their wholesomeness for human consumption. Nine metals, copper (Cu), chromium (Cr), zinc (Zn), manganese (Mn), iron (Fe), lead (Pb), nickel (Ni), cadmium (Cd), and silver (Ag) were analyzed on 50 fish samples (10 fishes per specie) to check the level of those trace metals in three major parts (gill, muscle and internal organs). The organs (liver) were observed to have the highest level of trace metals while the muscle tissue recorded lowest concentration. Some trace metals were not detected in all or some parts of the fish species. To eliminate and avoid the aquatic life loss as well as protect humans (consumers) there is need to use the advanced technologies generating less trace metal pollution to environment.

Keywords: Trace metals, Majidun river, Accumulation, Freshwater fish species, Organs

Introduction

Developing countries increasingly have many of the world's most serious air, water, and solid waste challenges as a result of decades of rapid urbanisation, population increase, and industry. Early studies have identified the rise in the pollution of trace metals in freshwater systems around the world, particularly in rivers. In recent years, there have been concerns about the contamination of aquatic environment and the attendant consequences on human health (Kelle *et al.*, 2015). The trace metal pollution has dreadful effects on the ecological equilibrium and a variety of aquatic entities (Akinmoladun *et al.*, 2007; Vosylien *et al.*, 2006), and the detrimental effects of these pollutants on fishes can never be negligible (Olaifa *et al.*, 1998; Clarkson, 1998). Heavy metals enter the fish and aquatic food chain in two main ways: direct intake of water and food (Oliveira Ribeiro *et al.*, 2005), and the contaminant bioaccumulation is higher in fish which is higher in the food chain (Adeyeye, 1996). The levels of heavy metals in fish usually reflect levels found in sediment and water of their aquatic environment (Nhiwatiwa *et al.*, 2011), and time of exposure (Annabi *et al.*, 2013). According to Annabi *et al.* (2013), fish can accumulate heavy metals in their tissues by absorption along gill surface and kidney, liver and gut tract wall to higher levels than environmental concentration. The toxic effects of heavy metals can affect the individual growth rates, physiological functions, mortality and reproduction in fish (Amunsden *et al.*, 1997). Fish has been recognized as an important food source for the human body and are known to provide essential fatty acids like Omega 3, proteins, vitamins, and minerals. However, despite its nutritional value, eating fish contaminated with heavy metals poses a health risk to humans. According to Jarup (2003), prolonged consumption of unsafe concentrations of heavy metals through foodstuff may lead to the chronic accumulations of the metals in the kidney and liver of humans causing disruption of numerous biochemical processes, leading to cardiovascular, nervous, kidney and bone diseases as heavy metals bioaccumulate.

The dependence of the populace in Majidun area of Ikorodu on fish as source of protein makes it imperative to assess the level of trace metals in this aquatic ecosystem in view of the health implications that cut across the food strata. Therefore, the present study was undertaken to investigate the level of trace metals, namely copper (Cu), chromium (Cr), zinc (Zn), manganese (Mn), iron (Fe), lead (Pb), nickel (Ni), cadmium (Cd), and silver (Ag) in 5 fish species selected from Majidun river.

Materials and Method

Description of the study area

Majidun River is relatively a small, narrow and shallow water body with average depth of 3 m. The river lies within latitudes 3°48'E and 4°48'E and stretches between longitudes 6°61'N and 7°12'N (Fig. 1 and Fig. 2). It is one of the numerous aquatic habitats that constitute Lagos lagoon complex. Others adjoining aquatic habitats include Ologe, Lekki and Epe lagoons, Yewa and Ogun rivers, Badagry and Ogudu creeks. However, Majidun river drains directly into Lagos Lagoon and empties into the Atlantic Ocean via Lagos Harbor. Due to seasonal distribution of rainfall, the river experiences seasonal flooding which introduces a lot of detritus, domestic and industrial wastes and pollutants from the mainland.

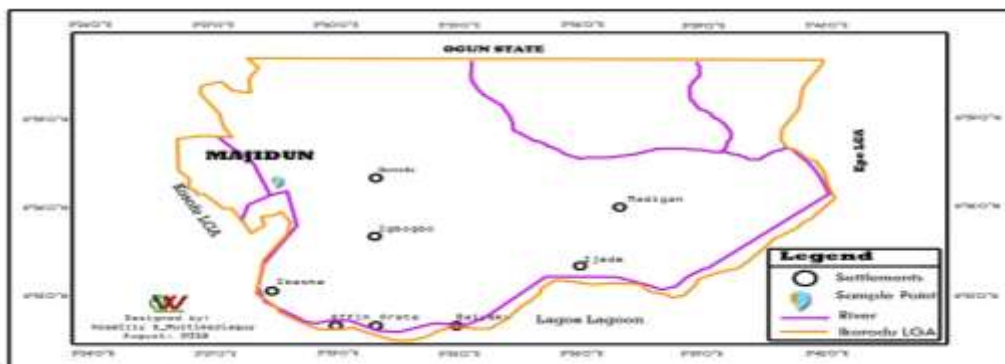


Fig. 1: Map of Majidun Ikorodu Lagos state showing the sample point of this study



Fig. 2: Satellite view of Majidun Ikorodu area of Lagos state

Sample collection and field procedure

50 fish samples (10 individuals per specie) were collected with the help of fishermen at the Majidun river during wet season. The 5 species considered are *Sarotherodon melanotheron* (Blackchin Tilapia), *Protopterus annectens* (West African Lungfish), *Parachanna obscura* (African snakehead), *Panathodon buchholzi* (Freshwater Butterflyfish), and *Eleotris picta* (**Spotted sleeper goby**). Fishing site was set at least 500 m away from the operational sand mining site and all captured fish were labelled individually and placed in a cooler with ice chest before transport to the research laboratory of Lagos State Environmental Protection Agency (LASEPA) for trace metal analysis. At the laboratory the specimen was sorted based on standard taxonomic keys for proper identification of fish species.

Preparation and digestion of fish samples

The fish samples were thawed at room temperature and then dissected to remove the parts (gills, organ, and muscle) needed for the analysis. One gram (1g) of each homogenized part (gills, intestine, kidney and muscle) taken from the samples was weighed in an Erlenmeyer flask and digested with 5 ml concentrated HNO₃ and 2ml of HCl on a hot plate until brown fumes ceased to evolve, then samples were cooled at room temperature, diluted with 50 ml distilled water by following (AOAC, 1995). These parts of fish samples were analysed employing the method of wet digestion and AAS, the level of metals in these parts of fish were determined after pre-treatment. Fish samples were analysed by following methods described in (AOAC, 1995) for the detection of metals through an Atomic Absorption Spectrophotometer (Hitachi Polarized Zeeman AAS, Z-8200, Japan). The blanks and calibration

standard solution were also analysed in the same way as for the samples. The instrument calibration standards were prepared by diluting standard (1000 ppm) supplied by Merck, Germany. All the samples were analysed for nine heavy metals, namely copper (Cu), chromium (Cr), zinc (Zn), manganese (Mn), iron (Fe), lead (Pb), nickel (Ni), cadmium (Cd), and silver (Ag) by using an atomic absorption spectrophotometer.

Results and Discussion

The concentrations of 9 trace metals in the organs, muscle, and gills of the 5 selected fish species from Majidun river levels are presented in Table 1. The highest concentration of all analysed metals was found in the organs (liver) while the lowest concentrations were found in muscle tissue. Fe showed the highest concentration in the organs of the 5 fish species, with highest value (101.418 mg/l) recorded in *P. obscura*. Fe and Mn were detected in all the analysed parts of the fish samples. Cd was not detected in any analysed part of all the fish samples. Zn, Cu and Ni were not detected in all analysed parts of *P. annectens*, *P. obscura* and *P. buchholzi* samples. Cr was also not detected in *S. melanotheron*, *P. annectens*, *P. buchholzi* and *E. picta*. The fish sample with lowest representation of heavy metals in it is *P. buchholzi* with just 4 trace metals (Fe, Pb, Mn and Ag) observed in them. The high trace metals concentration recorded in the organs (liver) and the low concentration recorded in the muscle tissues is consistent with the findings of similar studies (Rahed, 2001; Pyle *et al.*, 2005; Dural *et al.*, 2006; Storelli *et al.*, 2006; Ploetz *et al.*, 2007). Muscle is generally considered a tissue with little potential for bioaccumulation and is a tissue with the lowest metal content (Erdogru and Erbilir, 2007; Uysal *et al.*, 2009). The liver is a metabolically active and eliminative organ, due to the activities of metallothioneins, proteins with the ability to bind to specific metals, such as Cu, Cd and Zn, thereby reducing their toxicity and allowing for the accumulation of high metal concentrations (Wu *et al.*, 2006; Ploetz *et al.*, 2007; Uysal *et al.*, 2009).

Table 1. Concentration Of Heavy Metals In Different Tissues Of The Five Selected Fish Species

		<i>S. melanotheron</i>	<i>P. annectens</i>	<i>P. obscura</i>	<i>P. buchholzi</i>	<i>E. picta</i>
Zn (Mg/l)	Organs	0.2229	ND	ND	ND	ND
	Muscle	0.3707	ND	ND	ND	ND
	Gill	0.181	ND	ND	ND	0.5359
Fe (Mg/l)	Organs	54.5576	30.5495	101.418	17.6779	32.9635
	Muscle	5.6368	9.0874	6.7144	17.1278	5.0737
	Gill	9.4411	2.8664	6.2979	4.4167	9.8791
Pb (Mg/l)	Organs	0.7077	1.2461	1.6132	2.7879	1.8009
	Muscle	0.0774	1.4569	0.3404	ND	1.0002
	Gill	ND	0.6704	ND	0.2756	0.4787
Cr (Mg/l)	Organs	ND	ND	0.501	ND	ND
	Muscle	ND	ND	ND	ND	ND
	Gill	ND	ND	3591	ND	ND
Cd (Mg/l)	Organs	ND	ND	ND	ND	ND
	Muscle	ND	ND	ND	ND	ND
	Gill	ND	ND	ND	ND	ND
Cu (Mg/l)	Organs	ND	ND	ND	ND	0.193
	Muscle	ND	ND	ND	ND	ND
	Gill	ND	ND	ND	ND	ND
Mn (Mg/l)	Organs	1.2848	1.543	0.5022	2.4537	1.4149
	Muscle	1.4784	1.3204	2.2998	1.7339	1.2074
	Gill	3.1837	0.9782	1.2906	3.0228	1.6756
Ni (Mg/l)	Organs	ND	ND	ND	ND	ND
	Muscle	ND	ND	ND	ND	0.34
	Gill	ND	ND	ND	ND	ND
Ag (Mg/l)	Organs	0.2229	0.1699	ND	0.28	0.469
	Muscle	0.3707	0.3217	0.432	0.0147	0.1548
	Gill	0.181	0.255	0.4993	0.3347	0.5359

Conclusion

The trace metals were analysed in different organs like gills, organs and muscles of the fish inhabiting the natural aquatic habitat, and most of the trace metals are present in edible portion of fish. The pollution of aquatic habitat with anthropogenic activities are the major cause of aquatic loss and imbalanced food chain. To eliminate and avoid the aquatic life loss there is need to use the advanced technologies generating less heavy metal pollution to environment. Humans are also at risk as eating fish contaminated with heavy metals can cause a few of health problems.

References

- Adeyeye, E. (1996). Determination of major elements in *Illisha africana* fish, associated water and soil sediments from some freshwater ponds. *Bangladesh J Sci Indust. Res.* 31:171-184
- Akinmoladun, A.C., Ibukun, E., Afor, E., Obuotor, E. and Farombi, E. (2007). Phytochemical constituent and antioxidant activity of extract from the leaves of *Ocimum gratissimum*. *Sci. Res. Essay.* 2:163-166.
- Amundsen, P. A., Staldvik, F. J., Lukin, A. A., Kashulin, N. A., Popova, O. A. and Reshetnikov, Y. S. (1997). Heavy metal contamination in freshwater fish from the border region between Norway and Russia. *Sci. Total. Environ.* 201:211-224.
- Annabi, A., Said, K. and Messaoudi, I. (2013). Cadmium: bioaccumulation, histopathology and detoxifying mechanisms in fish. *Am. J. Res. Commun.*;1:60–79.
- Clarkson, T. W. (1998). Human toxicology of mercury. *J Trace Elem Exp. Med.* 11:303-317.
- Dural, M., Goksu, M. Z. L., Ozak, A. A. and Derici, B. (2006). Bioaccumulation of some heavy metals in different tissue of *Dicentrarchus labrax* L. 1758, *Sparus aurata* L. 1758 and *Mugil cephalus* L. 1758 from the Camlik Lagoon of the eastern coast of Mediterranean (Turkey). *Environ Monit Assess.* 118(1):65-74.
- Erdogrul, O. and Erbilir F. (2007). Heavy metal and trace elements in various fish samples from Sir Dam Lake, Kahramanmaraş, Turkey. *Environ Monit Assess.* 130(1):373-9.
- Jarup, L. (2003). Hazards of heavy metal consumption, *Pr. Med, Bull.* 68:167-182.
- Kelle, H. I., Ngbede, E. O., Oguezi, V. U. and Ibekwe, F. C. (2015). Determination of heavy metals in fish (*Clarias gariepinus*) Orgas from Asaba Major Markets, Delta State, Nigeria. *American Chemical Science Journal* 5(2): 135-147
- Nhiwatiwa, T., Barson, M., Harrison, A. P., Utete, B. and Cooper R. G. (2011). Metal concentrations in water, sediment and sharp tooth catfish *Clarias gariepinus* from three peri-urban rivers in the upper Manyame catchment, Zimbabwe. *Afr. J. Aquat. Sci.* 36:243–252.
- Olaifa, F., Olaifa, A. and Onwude, T. (1998). Lethal and sub-lethal effects of copper to the African catfish (*Clarias gariepinus*) Juveniles. *Afri J Biomed. Res.*7:45-53
- Oliveira Ribeiro, C. A., Vollaie, Y., Sanchez-Chardi, A. and Roche, H. (2005). Bioaccumulation and the effects of organochlorine pesticides PAH and heavy metals in the eel (*Anguilla anguilla*) at the Camargue Nature Reserve, France. *Aqua Toxicol.* 74:53–69
- Ploetz, D. M., Fitts, B. E. and Rice, T. M. (2007). Differential accumulation of heavy metals in muscle and liver of a marine fish, (King mackerel, *Scomberomorus cavalla* Cuvier) from the Northern Gulf of Mexico, USA. *B Environ Contam Tox.* 78(2):134-7.
- Pyle, G. G., Rajotte, J. W. and Couture, P. (2005). Effects of industrial metals on wild fish populations along a metal contamination gradient. *Ecotox Environ Safe.* 61(3):287-312.
- Rashed, M. N. (2001). Monitoring of environmental heavy metals in fish from Nasser Lake. *Environ Int.* 27(1):27-33.
- Storelli, M. M., Barone, G., Storelli, A. and Marcotrigiano, G. O. (2006). Trace metals in tissues of mugilids (*Mugil auratus*, *Mugil capito*, and *Mugil labrosus*) from the Mediterranean Sea. *B Environ Contam Tox.* 77(1):43-50.
- Uysal, K., Kose, E., Bulbul, M., Donmez, M., Erdogan, Y., Koyun, M., Omeroglu, C. and Ozmal, F. (2009). The comparison of heavy metal accumulation ratios of some fish species in Enne Dame Lake (Kütahya/Turkey). *Environ Monit Assess.* 157(1):355-62.
- VosylienA, M. Z. and JankaitA, A. (2006). Effect of heavy metal model mixture on rainbow trout biological parameters. *Ekologija.* 4:12-17
- Wu, S. M., Jong, K. J. and Lee, Y. J. (2006). Relationships among metallothionein, cadmium accumulation, and cadmium tolerance in three species of fish. *B Environ Contam Tox.* 76(4):595-600.

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Morphometry and Diet of *Chrysichthys nigrodigitatus* (Lecepede) In Majidun River, Ikorodu, Lagos State, Southwest, Nigeria

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Abstract

The morphometry and diet of *Chrysichthys nigrodigitatus* from Majidun river were investigated between October and December 2020, Ikorodu, Lagos state. The study was conducted to investigate the sustainability and availability of *Chrysichthys nigrodigitatus* one of the most commercial fish found in Majidun river. Total number of samples collected from fishermen landing site was 50 (fifty), the major fishing methods employed by the fishermen were cast netting and set netting. The total length ranged from 11.00 to 30cm (mean size 19.67 ± 4.56 cm) while the standard length ranged from 8.30 - 24.50cm (mean size 15.09 ± 3.39 cm). The length weight relationship was described by the equation: $\text{Log } W = 1.6373 + 2.88 \text{ LogSL}$ and the condition factor ranged from 1.49 – 3.60. The results were obtained from the study of the stomach contents of the specimens in the laboratory by visual and microscopic examinations. Analysis of the stomach content were done by combination of frequency of occurrence methods and numerical methods were used to study the food. Dietaries revealed five (5) identified food items and unidentified mass. Sediments was the most abundant food items by occurrence (34.70%) methods followed by unidentified mass (19.80%) while crustaceans, mollusks, fishes and insects were the least abundant with 17.82%, 16.83%, 6.93% and 3.92% respectively. Considering the numerical method, mollusks was the most abundant (97.4%), while insects was the least (0.23%). The population of males was significantly ($p < 0.05$) higher than females in the river.

Keywords: Growth pattern, food, sex ratio, Majidun river, Nigeria.

Introduction

The study of length-weight relationships, condition factor, fish diet and eating patterns is a continuous research project as it is the foundation for developing a successful fisheries management programme based on fish capture and culture, and because the aquatic ecosystem is dynamic. According to Bolarinwa and Popoola (2013), length-weight relationships provide important clues on climatic and environmental changes and the change in human subsistence practice. Condition factor is used as an index of growth and feeding intensity and decrease with increase in length (Fagade, 1979). The gut content reflects the water quality, all other factors being constant. The natural habitats offer a great diversity of organisms that are used as food by fish, which differ in sizes (microscopic and macroscopic) and taxonomy groups (Olojoet *et al.*, 2003). The dietary analysis of fish in their natural habitats enhances the understanding of the growth, abundance, productivity and distribute on of organisms (Fagade and Olaniyan, 1972).

The genus *Chrysichthys* represents one of the most abundance bagrid in major Rivers of Africa and is represented in Nigeria water by five species (Idodo-Umeh, 2005), which include *Chrysichthys nigrodigitatus* commonly known as silver catfish. According to Ekanem (2000), most of these *Chrysichthys* species have been reported to be of high commercial importance. *Chrysichthys nigrodigitatus* is widely distributed along the tropical and sub-tropical region (Francis and Sikoki, 2012; Hart and Abowei, 2007; Holden and Reed, 1991; Erundu, 1990; FAO, 1969). *Chrysichthys nigrodigitatus* is highly prized food-fish in Nigeria and is among the principal fishes of commercial catches as well as cultivable fish species from the wild (Ezenwaet *et al.*, 1986). Abowei and Ezekiel (2013) also reported *C. nigrodigitatus* to be of a great ecological and economic importance as they play important role in the food chain and provide food for the local communities and Nigerian as a whole. *C. nigrodigitatus* is a demersal, potamodromous specie and it occurs in shallow waters of lakes (less than 4 m), over mud and fine sand bottom, in rivers and in swamps. It is an omnivorous fish that feeds on bivalves, crabs, detritus, insects, and seed (Reed *et*

al., 1967). Feeding becomes specialized with size and age, larger fish may also feed on fish and decapods (Laleye, 1995).

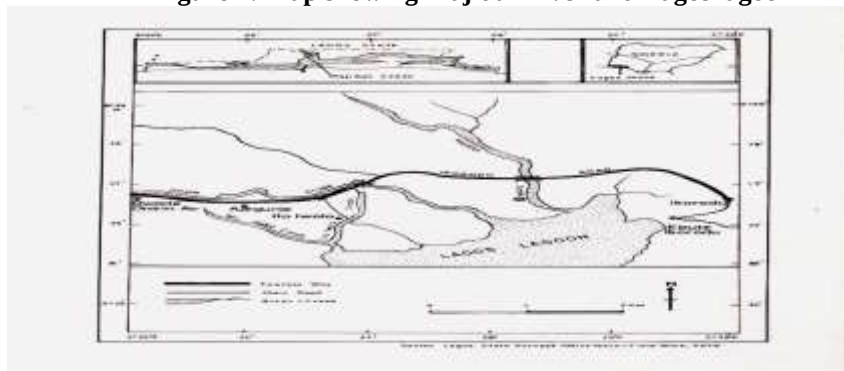
A general survey of the distribution of *C. nigrodigitatus* in Nigeria has shown that it is concentrated in the major rivers of the country and occurs in low brackish water, freshwater lagoon and creeks in the coastal areas of Nigeria (Ezenwa, 1978). Artisanal fishermen in most fishing communities in Lagos depends on the fish resource of *Chrysichthys* species which is among their major resource. Although considerable information is available on varied aspects of the length weight relationship, condition factor and gut content of *C. nigrodigitatus* in Nigeria waters (Ezenwa *et al.*, 1986; Ekanem, 2000; Atobatele and Ugwumba, 2011; Okey *et al.*, 2017), little information exist on this specie in the Majidun River at Majidun fish landing site. As a result, this study will be beneficial in the management of this valuable fish species in the Majidun River by providing information on its length-weight relationship, condition factor, and dietary composition.

Materials and Method

Description of study area

Majidun River is relatively a small, narrow and shallow water body with average depth of 3 m. The river lies within latitudes 3°48'E and 4°48'E and stretches between longitudes 6°61'N and 7°12'N (Figure 1). It is one of the numerous aquatic habitats that constitute Lagos lagoon complex. Others adjoining aquatic habitats include Ologe, Lekki and Epe lagoons, Yewa and Ogun rivers, Badagry and Ogudu creeks. However, Majidun river drains directly into Lagos Lagoon and empties into the Atlantic Ocean via Lagos Harbor. Due to seasonal distribution of rainfall, the river experiences seasonal flooding which introduces a lot of detritus, domestic and industrial wastes and pollutants from the mainland.

Figure 1: Map showing Majidun river and Lagos lagoon



Sample collection

Fifty (50) specimens of *C. nigrodigitatus* were collected at Majidun river with cast net, gill net, traps or hook and line, between October and December 2020. Immediately after collection, the fish samples were preserved in an ice chest containing ice cubes in the field and were transported to NIOMR Laboratory where they were stored in a deep freezer before further examination.

Fish measurement

The stored specimens were defrosted and wiped dry with towel before weighing to prevent excessive weights of the fish due to water droplets. The standard and total lengths were measured on a measuring board and the weights were determined using a sensitive weighing balance (Sartorius balance - Model 1106). The length measurement was recorded in centimeters while the weight measurements were recorded in grams. The total weight of each fish was achieved by placing each *C. nigrodigitatus* on the sartorius sensitive weighing balance and the result was recorded to the nearest decimal point in grams.

Stomach content analysis

Each specimen was dissected and gutted to determine food volume. The displacement method (Windell and Bowen, 1978; Hyslop, 1980) was used to determine the volume. Each gut was placed one after the other in a Petri dish in the laboratory containing known volume of tap water and the respective food volume reading (ml) were recorded with each of the standard length (cm) and weight (g) of each of the fish samples. The food content of the species was

analyzed using numerical and frequency of occurrence method (Hyssop, 1980). The stomach of each specimen was split open using a pair of dissecting scissors and emptied into the petri dish to determine its content. Three drops of the mixture (stomach content) were placed on a glass slide using a dropper. The slide was covered with a cover slip and viewed under a light microscope (Olympus) in order to identify the various food items.

Data analysis

The data collected was analyzed using SPSS (version 22).

The length – weight relationship of each fish was studied using the formula:

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

Where a = regression constant

b = regression coefficient

W = Weight (g)

L = Length (cm)

The condition factor (K) shows the state (well-being) of the fish i.e., the leanness or fattiness of a fish, (Gomiero and Braga, 2005) and was computed using the formular:

$$K = [100 W] / L^3$$

Where K = Condition factor

L = Standard length (cm)

W = Weight (g)

The diet components were summarized using descriptive statistics and data were presented in tables, graphs and charts.

Results

Length frequency distribution

The total length of *C. nigrodigitatus* from Majidun river range from 11.00 - 30.00cm (mean size $19.67 \pm 4.56\text{cm}$) while the standard length ranged from 8.30 - 24.50cm (mean size $15.09 \pm 3.39\text{cm}$).

Length – weight relationship of female *C. nigrodigitatus*

The weight of female *C. nigrodigitatus* range from 11.40 – 80.73g. The length and weight relationship reflected a common general increase in weight with increasing length. The least square common fit of the transformation of the data gave the following linear equation.

$$\text{Log } W = 1.5633 + 2.8085 \log SL$$

$$r = 0.85720, n = 17$$

Length – weight relationship of male *C. nigrodigitatus*

The weight of male *Chrysichthys nigrodigitatus* range from 12.50 – 102.62g. The length weight relationship reflected a common general increase in weight with increase in length. The least square common fit of the transformed data gave the following linear equation.

$$\text{Log } W = 1.1614 + 3.6784 \log SL$$

$$r = 0.98590, n = 33$$

Length – weight relationship of combined sex of *C. nigrodigitatus*

The weight of combined sex of *Chrysichthys nigrodigitatus* ranged from 14.60 – 106.52g. The length weight relationship reflected a common general increase in weight with increasing length. The least square common fit of the transformed data gave the following equation.

$$\text{Log } W = 1.6373 + 2.88 \log SL$$

$$r = 0.67856, n = 50$$

Condition factor (K)

The condition values ranged from 1.69 – 1.70, 1.86 – 1.97 and 1.97 – 3.60 for males, females and combined sex respectively. The mean K value were 1.64, 1.70 and 2.28 for males, females and the combined sex respectively.

F = Frequency; SL = mean standard length (cm), W = mean weight (g) and K = mean condition factor

Stomach food volume

The result of the stomach food volume in the samples of *C. nigrodigitatus* from Majidun river is shown in Table 1. While Table 2 shows stomach condition of different size range of *Chrysichthys nigrodigitatus* from Majidun river. 30% of the sampled population have empty stomach while 12% have their stomach full.

Table 1: Stomach food volume of *C. nigrodigitatus* from Majidun river

State of stomach	No of stomach	Percentage volume
Empty	15	30
$\frac{1}{4}$	20	40
$\frac{1}{2}$	8	16
$\frac{3}{4}$	1	2
Full	6	12
TOTAL	50	100

Table 2: Stomach condition of different size range of *C. nigrodigitatus* from Majidun river

Standard Length (cm)	Empty	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	Full	TOTAL
11.50 - 14.40	2	1	-	-	-	3
14.50 - 17.40	2	5	2	-	-	9
17.50 - 20.40	4	9	4	-	1	18
20.50 - 23.40	5	4	2	1	3	15
23.50 - 26.40	2	1	-	-	-	3
26.50 - 29.40	-	-	-	-	2	2
TOTAL	15	20	8	1	6	50

Food items found in the gut of *C. nigrodigitatus*

A total of 50 Fish, 33 (66%) males and 17 (34%) females were caught during the study. Food was present in the gut of *Chrysichthys nigrodigitatus*. The summary of stomach content of *Chrysichthys nigrodigitatus* is presented in Table 3 and Table 4. 50 stomachs examined, fifteen stomach (30%) were empty, mollusks remain the most important food item accounting for 94.4% and 16.83 by numerical and occurrence methods while crustaceans (1.98% in number and 17.82% in occurrence) and fish (0.39% in numbers and 6.93% in occurrence) made up the next food group in order of importance. The insects claim (0.23% in number and 3.92% in occurrence) were the next group. Other items encountered in the stomach were sediments (0% in number and 30% in occurrence) and unidentified mass were 0% in number and 19.80% in occurrence, respectively.

Table 3: Numerical analysis of food preference of *C. nigrodigitatus* from Majidun river

Food items	Number of food item	% number
Insects	6	0.23
Fish	10	0.39
Crustaceans	51	1.98
Molluscs	2509	97.4
Sediment	-	-
Unidentified mass	-	-
TOTAL	2576	100

Table 4: Frequency of occurrence of food items found in *C. nigrodigitatus* from Majidun river

Food items	No of stomach	Percentage (%)
Insects	4	3.92
Fish	7	6.93
Crustaceans	18	17.82
Molluscs	17	16.83
Sediment	35	34.7
Unidentified mass	20	19.8
TOTAL	101	100

Discussion

The length frequency distribution showed a single mode, and this depicted that the species was made of one age group during the study period. The length weight relationship of *Chrysichthys nigrodigitatus* reflected an income in weight with corresponding increase in length. The value of the regression coefficient (b) is approximately 1 which show that the species exhibit meristic growth in Majidun river (Bagenal and Tesch, 2008). The correlation coefficient (r) of 0.85720 showed a positive correlation between length and weight. There was a general decrease in the condition factor with increasing length of the specimens. This is due to the landing of mainly sexually immature and juvenile fishes which are in active growth stage of their life cycles. However, the mean condition factor of 1.70 obtained from the population of *Chrysichthys nigrodigitatus* in Majidun river is higher than 0.9673, 0.9159 and 0.7859 reported from Badagry lagoon, Warri River and Imo River respectively (Ezenwaet *al*, 1986) and 0.996 reported for Cross river (Offemet *al*, 2008). This is an indication of the food condition of the specimen (Bannister, 2006), therefore *Chrysichthys nigrodigitatus* from Majidun River would provide excellent brood-stocks for agriculture elsewhere. The feeding habit of any fish is often reflected in its general morphology. The general morphology of *Chrysichthys nigrodigitatus* suggest that it's an efficient bottom feeder although stomach content of fish often reflect the ability of fish to obtained food item from different locations. *Chrysichthys nigrodigitatus* in Majidunriver feeds on a variety of food items of which insects, fish, crustaceans, sediments, unidentified mass and mollusk were the primary importance and food items that probably serve as indicating that *Chrysichthys nigrodigitatus* is an omnivorous feeder, similar result has been obtain for *Chrysichthys nigrodigitatus* by (Udoh and Ekpo, 2017) in the lower river and from Lekki lagoon (Ugwumba and Kusemiju, 2007). This is an indication of flexibility in tropic levels which gives the fish an ecological advantage to feed effectively on different categories of diet based on the availability of food items. Similar observation had earlier been recorded by Yem (2009) and George and Atakpa (2015).

Conclusion

The silver catfish *Chrysichthys nigrodigitatus* is an omnivorous as it fed on a variety of food items. Unidentified mass formed ability increased potion of the stomach fullness. They relied on the same food item at juvenile and adult stage which were dominant throughout the study period, this information is useful in the formation and production of diet for the culture of this specie.

References

- Abowei, J. F. N. and Ezekiel, E. N. (2013). The Length-weight relationship and condition factor of *Chrysichthys nigrodigitatus* (Lacepède, 1803) from Amassoma River flood plains. *Sci Agri* 3: 30- 37.
- Atobatele, O. E. and Ugwumba, A. O. (2011) Condition factor and diet of *Chrysichthys nigrodigitatus* and *Chrysichthys auratus* (Siluriformes: Bagridae) from Aiba Reservoir, Iwo, Nigeria. *Rev. Biol. Trop. (Int. J. Trop. Biol.)*, 59(3):1233-1244.
- Ayoola, S. O. and Abotti, C. E. 2010. The morphology of Aba knife fish (*Gymnarchus niloticus*) (Cuvier, 1929). *World Journal of fish and marine science*, 2(5):354- 356.
- Bagenal, T. B. (2008). Aspects of fish fecundity. In: Methods of Assessment of Ecology of Freshwater fish production (Ed. Gerking SD). Blackwell Scientific Publication, Oxford, pp. 75-101.
- Bagenal, T. B. and Tesch, F. W. (2008). Age and growth. In: Methods of Assessment of Fish Production in Freshwater (Bagenal TB ed). Blackwell Science Publication Oxford, pp. 101-136.
- Bannister, J. V. C. (2006). The length-weight relationship, condition factor gut contents in the dolphin fish *Coryphaenahippurus* (L) in the Mediterranean. *J. Fish Biol.* 9: 335-338.
- Bolarinwa, J. B. and Popoola, Q. (2013). Length-Weight Relationships of Some Economic Fishes of Ibeshe Waterside, Lagos Lagoon, Nigeria. *J Aquac Res Development* 5: 203
- Buddington, R. K., Krogdahl, A. and Bakke-Mckellep, A. M. (1997). The intestines of carnivorous fish: structure and functions and the relations with diet. *Acta Physiological ScandnavicaSupplementum.*, 638:67-80.
- Ekanem, S. B. (2000). Some reproductive aspects of *Chrysichthys nigrodigitatus* (Lacepede) from Cross River Nigeria. *NAGA, the ICLARM Quarterly* 23: 24-27.
- Erundu, E. S. (1997). Some aspect of the biology of *Chrysichthys nigrodigitatus* in the New Calabar River and its aquaculture potentials PhD Thesis, University of Nigeria Nsukka. Enugu state, 101-109.
- Ezenwa, B. I. O., Kusemiju, K. and Olaniyan, C. I. O. (1986). Comparative studies of the catfish, *Chrysichthys nigrodigitatus* (L) in three isolated geographical areas in Nigeria for breeding purpose. *Aquat. Res. Afr. Reg. J.* 1: 258-262.
- Ezenwa, B. I. O. (1978). Studies on the distribution, age and growth of the catfish, *Chrysichthys nigrodigitatus* (L.). M.Sc. Thesis, University of Lagos, Nigeria.

- Fagade, S. O. and Olaniyan, C. I. O. (1972). The biology of the West African shad, *Ethmalosa fimbriata* (Bowdich) in the Lagos lagoon, Nigeria. *J Fish Biol*; (4):519-533.
- Fagade, S. O. (1979). Observation on the species of two species of Tilapia from the Lagos, Lagoon, Nigeria. Bulletin de l'I FANT; 41 Ser A No 3.
- FAO (1969). Fisheries survey in the western and mid-western regions of Nigeria. FAO/SF74/NIR6.
- Francis, A. and Sikoki, F. D. (2012) Length weight relationship of fish species from the the Andonni River system, Niger Delta, Nigeria. *Journal Environment & Ecology*, 25 (2): 439-443.
- George, U. U. and Atakpa, E. O. (2015). Food and Feeding Ecology of *Chrysichthys nigrodigitatus* in the Cross River Estuary, South Eastern Nigeria. *New York Science Journal*, 8(11): 86-90
- Hart, A. I. and Abowei, J. F. N. (2007). A study of the length weight relationship, abundance, condition factor and age of ten fish species from the upper Orashi River. Niger Delta, Nigeria. *African Journal of Applied Environmental Biology*, 9:13-19.
- Holden, M. and Reed, W. (1991). West African Freshwater Fish. Longman Publishers Ltd., Singapore. p. 68.
- Hyslop, E. J. (1980). Stomach content analysis-a review of methods and their application. *Journal of Fish Biology* 17, 411-429
- Idodo-Umeh, G. (2005). The feeding ecology of Mochokid species in River Ase, Niger Delta, Nigeria. *Trop Freshwat Biol* 14: 71-93.
- Idodo-Umeh, G. (2003). Freshwater fishes of Nigeria (Taxonomy, ecological notes, diet and utilization). Idodo-Umeh, Benin City, Edo State, Nigeria.
- Lagler, K. F., Bardach, J. E., Miller, R. R and May Passino, D. R. (1977). *Ichthyology*. 2nd Edition. Wiley and sons Inc. printed in USA. Pp.129 - 163.
- Laleye, R. (1995). Climatic and anthropogenic effects on fish diversity and yields in the Central Delta of the Niger River. *Aquat. Living Res.*; 8: 43-58.
- Offem, B. O., Samson, A. Y. and Omoniyi, I. T. (2008). Diet, size and the reproductive biology of the silver catfish *Chrysichthys nigrodigitatus* (Siluformes: Bagridae) in the Cross River Nigeria. *International Journal of Tropical Biology*, 56 (4):1785-1799.
- Okey, I., Offem, B.O. and Keremah, R. I. (2017). Length-Weight Relationship, Condition Factor and Gut Content of *Chrysichthys furcatus* Gunther, 1864 (Bagridae) from Cross River at Ahaha. *Fish Aqua J* 8: 228. doi:10.4172/2150-3508.1000228

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Water Quality Parameters and Plankton Assemblage in Efi Lake, Sabagreia, Bayelsa State**Lamien Bishop Seikorowei and Azikiwe J.T. Otobotekere**

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Abstract

Water quality parameters and plankton assemblage were investigated in Efi Lake, Sabagreia, Bayelsa State. Water quality parameters were measured in-situ. Plankton samples were collected with plankton net, preserved in formalin, and the species identified and enumerated in a counting chamber under a microscope at X40 and X100 magnifications. A total phytoplankton estimate of $252.67 \times 10^3 \text{ml}^{-1}$ comprising 38 species in 5 divisions including Bacillariophyta (34.03 %), Cholorophyta (25.72%), Cyanophyta (24.72%), Euglenophyta (10.30%) and Xantophyta (1.75%) was obtained. Total zooplankton estimate was $106.54 \times 10^3 \text{ml}^{-1}$ with 12 species in 3 divisions; Rotifera (64.54%), Cladocera (29.67%) and Copepoda (5.78%). Phytoplankton abundance ranged from 36.84 ± 0.68 in Station 2 to $51.83 \times 10^3 \text{ml}^{-1}$ in station 4 with a mean of $44.14 \times 10^3 \text{ml}^{-1}$ ($F_{.05} = 3.94$) and zooplankton numbers ranged from $14.51 \times 10^3 \text{ml}^{-1}$, Station 5 to $23.87 \times 10^3 \text{ml}^{-1}$ in station 1 with mean value of $17.63 \times 10^3 \text{ml}^{-1}$ ($F_{.05} = 19.45$). Monthly values of phytoplankton ranged from $34.96 \times 10^3 \text{ml}^{-1}$ in the month of April to $62.61 \times 10^3 \text{ml}^{-1}$ in the month of December with a mean of $43.45 \times 10^3 \text{ml}^{-1}$ ($F_{.05} = 6.72$) and zooplankton numbers ranged from $14.52 \times 10^3 \text{ml}^{-1}$ in the month of February to $19.33 \times 10^3 \text{ml}^{-1}$ in the month of December with mean value of $17.5 \times 10^3 \text{ml}^{-1}$ ($F_{.05} = 6.46$). Water pH, temperature and transparency correlated negatively while dissolved oxygen correlated positively, with plankton. The Lake exhibits oligotrophic characteristics.

Keywords: Plankton, Physio-chemical parameters, Efi Lake, Oligotrophy.

Introduction

The biodiversity of any aquatic ecosystem is inter-twinning with the water quality (Abubakar, 2013). Kigbu and Mohammed (2014) defined water quality as the suitability of water for the survival and growth of aquatic organisms like fish. Water quality gives a clearer view of the resources available that could support life in the aquatic ecosystem (Ikongbeh, *et al.*, 2014). The growth, survival and reproduction of fish to sustain species standing stock biomass and maintain the health status of fisheries is hinged on good water quality (Abubakar, 2013). Physico-chemical properties of the water plays an essential role in the distribution pattern and species composition of flora and fauna in the lake ecosystem (Ikongbeh, *et al.*, 2014). According to Kigbu *et al.* (2015) physico-chemical parameters pose a great influence on the wellbeing of aquatic species. Plankton are organisms that wander, thus referring to all pelagic forms that are carried by movement of water rather than their ability to swim (Ogbuagu and Ayoade, 2012). Plankton plays a critical role in the biochemical cycle of important elements such as carbon, nitrification, denitrification, demineralization and methanogenesis in the aquatic ecosystem (Agouru and Audu, 2012). Their relative small size, inability to swim and quick response to changes in their environment makes them suitable for evaluating pollution level (Odunlate, *et al.*, 2019).

Bayelsa State is located in the southern part of Nigeria; the State has abundant water bodies which serve as sources of livelihood to inhabitants of adjacent communities and others. Most of the people are fishers but recent exploration of crude oil and urbanization has led to pollution of water bodies which results in the alteration of ecological structures within the water bodies (Otobotekere, 2012; Wangboje, 2015). Despite being blessed with these vast water bodies there is dearth of information on the various bodies of water. Proper studies and management of water bodies are needed to keep them in a healthy state, this can increase domestic fish production to enhance employment of both skilled and unskilled labour and increase Bayelsa State and Nigeria's GDP. There has been assessment of water quality parameters and plankton communities on different water bodies within the Niger Delta and the Country at large such as Forcados River (Ansa *et al.*, 2015), Lekan Aare lake, Abeokuta (Odunlate, *et al.*, 2017), Kabba/Bunu Local Government Area, Kogi State (Adesalu, *et al.*, 2017), lower Taylor Creek (Ogamba, *et al.*, 2019). No work has been carried out to document water quality parameters and plankton in Efi Lake, an emerging eco-tourist zone with a fishing festival, hence the current study.

Materials and Methods

The study was carried out in Efi Lake located between Latitude 5° 2' 10.75'' N, 5° 2' 28.29'' N and Long 6° 15' 2.7'' E, 6° 15' 29.3 E, behind Sabagreia Community in Kolokuma/Opokuma Local Government Area of Bayelsa State (Plate 1). The Lake has a total surface area of about 211, 263 m². It is an open water body with riparian vegetation typical of rain forests as the trees form a canopy around the lake. The Lake is a tourist center containing wild life, with a fishing festival held at determined times by the Lake owners. Efi Lake is a beauty to behold, retaining most of its natural features, with two satellite lakes connected to it. No serious fishing or forms of anthropogenic activities are carried out in the Lake except for few fishers fishing with spears and those who use the Lake as a transit route to access hinterlands for farming. It is believed to hold divers aquatic life including crocodiles, which are said to bask in the sun during the dry season.

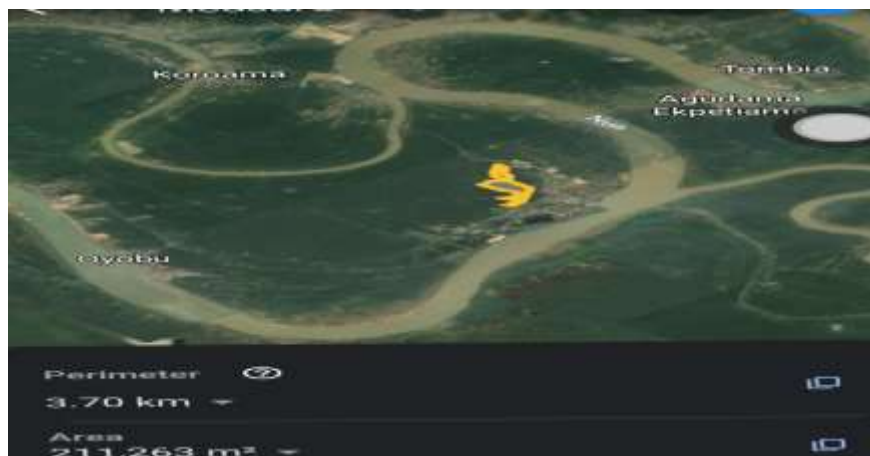


PLATE 1: Satellite imagery of Sabagreia community showing of Efi Lake (Google Earth @2021)

Six (6) sampling sites were selected based on ecological factors and anthropogenic activities. Station 1 was located at Lat 5° 2' 19.62'' N and Long 6° 15' 2.7'' E. Station 2 was located at Lat 5° 2' 26.25'' N and Long 6° 15' 6.86'' E. Station 3 was located in Lat 5° 2' 28.29'' N and Long 6° 15' 14.96'' E. Station 4 was located at Lat 5° 2' 17.93'' N and Long 6° 15' 23'.35'' E at North Western end by the side of the lake. Station 5 was located on Lat 5° 2' 10.75'' N and Long 6° 15' 29.3'' E Station 6 was located on Lat 5° 2' 19.002'' N and Long 6° 15' 3.9'' E.

Samples were collected once a month for a period of Six (6) months from November 2019 to April 2020. Water quality parameters including Temperature, Dissolved Oxygen (DO), Hydrogen ion Concentration (pH), Transparency, Depth, Salinity, Total Dissolved Solid and Conductivity were measured in-situ using a multifunctional water quality analyzer (EC900 Model). Temperature and Dissolved Oxygen (DO) were measured using a multifunctional DO meter (Model Ohauster Stater 300d). pH was measured with pH meter (Model Ohaus ST10). Transparency and Depth were measured with a Secchi disk. Plankton samples were collected by towing a plankton net of 60µ at a low speed from a hand paddled canoe, contents of the net were washed into the bottle of the plankton net, preserved in 1% formaldehyde solution and taken to the laboratory for sedimentation and analysis (Ansa, *et al.*, 2015).

In the laboratory, the plankton samples were allowed to stand for 24 hours to get a clear supernatant which was decanted off, and a 1ml volume pipetted into a Sedge-Wick rafter counting chamber and examined under the microscope at magnification (40, and × 100). Identification of plankton was carried out using identification keys (Nwadiaro, 2007a, b; Nwadiaro and Okafor, 2007). Enumeration and estimation of individuals and colonies of plankton number per volume was done using $N = (a1000)c/L$ (Okame, *et al.*, 2013). One-way analysis of variance (ANOVA) was used to test for significance of variations of water quality parameters and plankton at 95% confidence level. Pearson's Correlation Coefficient was used to determine the relationship between water quality parameters and plankton abundance. Data were analyzed using Microsoft excel and SPSS software.

Results and Discussion

The general water quality parameters reported for Efi Lake in comparison to local and international standards is presented in Table 4.1

The physicochemical (water quality) parameters to a large extent play a critical role in the variation and abundance of biological organisms within an ecosystem. The types of organism that are found in a particular environment is a function of physical and chemical parameters of the environment such as temperature, transparency, pH, water flow, shelter, nutrient load, etc (Odulate, *et al.*, 2017). The hydrogen ion (pH) mean value of 7.45 ± 0.2 is within the range for inland waters (6.5 - 8.5), as reported by Mahar (2003). Temperature has a direct effect on dissolved oxygen content of the water thereby determining which organisms can survive in a water body. Results of temperature in this study agreed with reports that temperatures in tropical lakes and rivers vary between 21°C and 32°C (Odulate, *et al.*, 2017). Dissolved oxygen (DO) is vital for biological organisms in the aquatic ecosystem, (Usman, 2015). Bhatnagar and Devi (2013) recommended dissolved oxygen of above 5 mg l^{-1} and results from the present study falls within this range.

Table 1 Water Quality parameters of Efi Lake alongside standard limit for WHO (2010) and NSDWQ (SON, 2007)

Parameters	Range	Mean S/D	$\pm$	WHO (2010)	NSDWQ	REMARK
pH	5.43-9.5	7.46 ± 0.2		5.5-9.0	6.5-8.5	A
Temperature ($^{\circ}\text{C}$)	28.3-32.5	30.3 ± 0.1		15-35	Ambient	A
Dissolved Oxygen (mg l^{-1})	3.86-7.9	5.8 ± 1.02		5.0-8.0		A
Salinity (‰)	-1.8- 2.31	0.2 ± 0.11				NS
Conductivity ($\mu\text{S/cm}$)	73.86-77	75.8 ± 0.3		10-1000	1000	A
Total Dissolved Solids (ppm)	49.7-53.75	51.73 ± 0.8		<500	500	A
Transparency (cm)	8.3-12.4	10.35 ± 1.4		20-80		A
Depth (m)	0.5-3.5	1.5 ± 1.26				NS

WHO = World Health Organization, 2007; NSDWQ = Nigerian Standard for Drinking Water Quality (SON, 2007); A = Acceptable, NS = No Standard Available

Salinity regulates osmotic pressure of organisms especially fish and they operate within a narrow range. The mean salinity of 0.2 ± 0.11 ‰ in Efi Lake is typical of freshwater bodies and conducive for freshwater organisms (Usman, 2015). Electrical conductivity value of 73.86 to 77 ($\mu\text{S/cm}$) with a mean of 75.8 ± 0.3 ($\mu\text{S/cm}$) compares well with those of Osimen *et al.* (2015) who reported electrical conductivity of 50-150 ($\mu\text{S/cm}$) as range for fresh water ecosystem. Mean value of total dissolved solids from the present study (51.73 ± 0.8 ppm) compares favorably with work by Osimen, *et al.* (2015) who reported total dissolved solids values between 49.04-56.74 ppm for Ojirami Reservoir. Transparency (cm) is very important because dissolved solids can clog fish gills resulting in difficulty in respiration and ultimate death, also causes siltation and smothering of benthos and interfere with filter feeding organisms like zooplankton and bivalve (Usman, 2015). Depth (m) values for the study range from 0.05-3.5 (m) with a mean of 1.5 ± 1.26 were low when compared to those from Orijimi Reservoir in Edo state (2.65 ± 0.85 - 3.37 ± 0.91 m) (Osimen, *et al.*, 2015). November was the deepest month a mean value of 2.7 ± 0.83 m as a result of drains the Lake shed received during the high flood.

A total of 5 divisions comprising of 38 species of phytoplankton was recorded in the study (Table 2). Bacillariophyta ($85.99 \times 10^3 \text{ ml}^{-1}$) represented 34.03 % of plankton composition by number, followed by Chlorophyta with $64.99 \times 10^3 \text{ ml}^{-1}$ (25.72 %), Cyanophyta had $62.47 \times 10^3 \text{ ml}^{-1}$ (24.72 %), Euglena $26.03 \times 10^3 \text{ ml}^{-1}$ (10.30 %) and Xanthophyta ($13.19 \times 10^3 \text{ ml}^{-1}$) making up 5.22% of phytoplankton abundance. There was significant difference ($p < 0.05$) in phytoplankton abundance. The number of species from this study is in line with 32 species reported from Forcados River by Ansa *et al.* (2015); 34 species from Ikoweri Lake (Offem *et al.*, 2011) but different from 54 species from Aare Lake (Odunlate *et al.*, 2017), 89 species from Sumn lake; 97 species from Glebokie lake; 102 species Massluchowskie lake (Pasztalec and Poniewozike, 2010).

Table 2. Number ((No ×10³ml⁻¹) composition of phytoplankton in Efi Lake

Divisions	No. of Family	No×10 ³ ml ⁻¹
Bacillariophyta	13	85.99
Clorophyta	11	64.99
Cyanophyta	10	62.47
Euglenophyta	3	26.03
Xanophyta	3	13.19
Total	38	252.67

Table 3. Number ((No ×10³ml⁻¹) composition of zooplankton in Efi Lake

Division	No. of Family	No ×10 ³ ml ⁻¹
Rotifera	7	68.76
Cladocera	4	31.62
Copepoda	1	6.16
Total	13	106.54

This difference in species composition and abundance could be due to climate conditions and regional difference in sampling location. Diatoms were the most dominant division by number and percentage composition, this is a common occurrence in tropical waters as reported by Ogbuagu and Ayoade (2012) in Imo River; Ansa *et al.* (2015) in Forcados River and Ogamba *et al.* (2019) in Taylor Creek as they are the most important phytoplankton group in clean water, however, Kigbu, *et al.* (2015) and Afolabi (2017) reported chlorophyte dominance. Odunlate, *et al.* (2017) reported bacillariophyta as water quality indicator. Three (3) divisions of zooplankton with twelve (12) families were recorded in the current study (Table 3). Rotifera 68.76×10³ml⁻¹ constitutes 64.54% of the zooplankton community in the Lake, Cladocera recorded 31.62 ×10³ml⁻¹ making up 29.69% while Copepoda recorded 6.16 ×10³ml⁻¹ making up 5.78% of the zooplankton composition. Zooplankton abundance showed significant difference (p<0.05) in stations and months. This dominance of Rotifera is typical of tropical waters as reported by Imoobe and Akom (2009) from Bashir Dar Gulf of Lake Tana, Ethiopia; Imoobe and Adeyinka (2010) in tropical forest river, Nigeria; Ekpo *et al.* (2015) from tropical rainforest River in Niger Delta; Kigbuet *et al.* (2015) Amba lake, Nassarawa. Workers such as Usman (2015) and Erundu and Solomon (2017) reported Cladocera dominance from Wawam-Rafi Lake, Kazaure, Nigeria and Behind Girls' Hostel, University of Abuja respectively. Imoobe and Adeyinka (2010) stated that Rotifera is the most abundant planktonic fauna in oligotrophic and mesotrophic waters while Ekpo *et al.* (2015) reported that Rotifera abundance in an aquatic ecosystem is due to their parthenogenetic reproductive system, development under favourable conditions. Zooplankton had negative relationship with phytoplankton, this could mean that the zooplankton regulates the excess growth of phytoplankton by grazing on them.

Increase in water quality parameters such as pH, temperature and transparency with the exception of dissolved oxygen reduces plankton abundance.

Conclusion

Physico-chemical properties (water quality parameters) reported from this study are within recommended range for biological organism survival. The low species composition of plankton and Bacillariophyta dominance observed in this study could be a pointer that Efi lake is an oligotrophic lake with low amount of nutrient pollutants. The presence of small size zooplankton (Rotifera) abundance is a common feature of standing water bodies.

References

- Abubakar, U.M. (2013). Physico-chemical Properties in Relation to Fish Production of Dadin Kowa Dam, Gombe State, Nigeria. pp 211-213. Proceedings of the 28th Annual Conference of Fisheries Society of Nigeria, November 25-29, Abuja, Nigeria
- Ansa, E.J., Kingdom, T. and Seikorowei, L.B. (2015). Checklist of Plankton of Forcados River Niger Delta, Nigeria. *Nigeria Journal of Fisheries*. 12 (2): 962 - 966
- Adesalu, T. (2012) Effects of Physico-chemical Parameters on Phytoplankton of a Tidal Creek, Lagos, Nigeria. *Journal of Environment and Ecology*, 3 (1): 116 – 136.

- Agouru, C.U. and Audu, G (2012). Studies on the Range of Plankton in River Benue, North Central Nigeria, West Africa. *Greener Journal of Biological Science*. 2 (2): 028-034.
- Bhatnagar, A. and Devi, P. (2013). Water Quality Guidelines for the Management of Pond Fish Culture, *International Journal of Environment Science Volume* 3(6): 216-220
- Ekpo, I.E., Essien-Ikok, M.A. and Duncan, A.O. (2015). Interaction between Bacterial Load Physicochemical Parameters of Odor Stream, Akwa-Ibom state Nigeria using Multivariate analysis. Pp 104-108. Proceedings of the 30th Annual Conference of Fisheries Society of Nigeria, 23rd – 27th November, Asaba, Delta State, Nigeria.
- Erondu, C. J. and Solomon, R. J. (2017). Identification of Planktons (Zooplankton and Phytoplankton) behind Girl's Hostel University of Abuja, Nigeria. *Direct Research Journal of Public Health and Environmental Technology*, 2 (3):21-29.
- Ikongbeh, O.A., Tiamiyu, L. O., Ayuba, V.O. and Okayi, R.G. (2014). Water Quality Parameter of Lake Akata, Benue State, Nigeria. Pp 278-285. Proceedings of the 29th Annual Conference of Fisheries Society of Nigeria, 24th – 29th November, Makurdi, Benue State, Nigeria.
- Imoobe, T. O. T. and Adeyinka, M. L. (2010): Zooplankton-based Assessment of the Trophic state of a Tropical Forest River. *International Journal of Fisheries and Aquaculture* 2 (2): 064-070.
- Kigbu, A.A. and Mohammed, U.S. (2014). Physic-chemical Parameters and Fish Abundance of Amba in Lafia, Nasarawa State. Pp 272-276. Proceedings of the 29th Annual Conference of Fisheries Society of Nigeria, 24th – 29th November, Makurdi, Benue State, Nigeria.
- Kigbu, A.A., Lawee, A.Y. and Jatau, A.M. (2015). Studies of Physic-Chemical Parameters of Shabu Stream in Nassarawa State. Pp 27-32. 'Proceedings of the 30th Annual Conference of Fisheries Society of Nigeria, 23rd – 27th November, Asaba, Delta State, Nigeria.
- Nwadiaro, C.S. (2007a). Microscopic and Planktonic Fauna of Nigeria's Inland Waters - Study of Methodologies, Guides. Review, Checklist and Atlas. University of Port Harcourt Press. 100pp.
- Nwadiaro, C.S (2007b). Crustacea: Branchiopoda, Copepoda, Ostracoda and Decapoda of the Sahelo-Sudanian Africa. French to English translation. University of Port Harcourt Press. 112pp.
- Nwadiaro, C.S. and Okafor, P.T. (2007). Algae of sahelosudaanian Africa (By A.Iltis) In: Flore et Fauna auquatique de L'Afrique Sahelo-Sudannienne (eds: J.R. Durand and C.Leveque, 1981), Orstom, Paris, France. University of Port Harcourt Press. 69pp.
- Odunlate, D.O., Oladoye, A.O., Omoniye, I.T., Edun, O.A., Busar, R.A. and Ajagbe, S.O. (2017). Diversity of Phytoplankton Community and Water quality in Lekan Aare Lake, Abeokuta, Nigeria. *Nigerian Journal of the Fisheries*, 14(2/3): 1108 - 1119
- Ogamba, E.N., Charles, E.E. and Izah, S.C. (2019). Phytoplankton Community of Taylor Creek in the Niger Delta using diversity indices. *Journal of Plant and Animal Ecology*, 1 (3): 1-12.
- Ogbuagu, A.E. and Ayoade, A.A. (2012). Phytoplankton Assemblage along Gradient of the Imo River in Etche Local Government Area, Nigeria. *Annals of Biological Research* 3 (4): 1852-1862.
- Osimen, , Elakhame, L.A. and D. Normamiukor (2015). E.C. Water Quality and Seasonal Variations of Physico-Chemical Parameters of Ojirami Reservoir, Edo State, Nigeria. Pp 94-98. Proceedings of the 30th Annual Conference of Fisheries Society of Nigeria, 23rd – 27th November, Asaba, Delta State, Nigeria.
- Otobotekere, A.J.T. and Kenigua, V.S. (2012). Occurrence and Distribution of Macro benthic Invertebrates in Lower Taylor Creek, Bayelsa State. Pp 315-318. Proceedings of the 27th Annual Conference and Biennial General Meeting of The Fisheries Society of Nigeria, 25th – 30th November, Bayelsa state, Nigeria.
- Wangbeje, O.M. (2015). Pre-urban concentration of Heavy Metals in Sediments, Fish and Water from Ikpoba Reservoir Nigeria. Pp 109-117. Proceedings of the 30th Annual Conference of Fisheries society of Nigeria, 23rd – 27th November, Delta.
- Usman, A. (2015) Determination of Physico-Chemical Parameters and Plankton Composition in Wawam-Rafi Lake in Kazaure, Nigeria. 'A Thesis submitted to the School of Post Graduate Studies Amadu Bello University, Zaria in partial fulfillment of the requirement for the award of Master of Science in Education Biology' pp 1-93

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Comparative Study on the Length-Weight Relationships of *Mormyrus Rume* and Physico-Chemical in Kainji Lake and River Rima

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Abstract

The study of length-weight relationships, condition factor, of *Mormyrus rume* in Kainji Lake and River Rima as well as the physico-chemical parameters of the water bodies were carried out from January, to December 2018. Five hundred and thirty one (531) samples from Kainji Lake and four hundred and seventy seven (477) samples from River Rima (making a total of 1,008 samples), were collected from fish landing site and subjected to Standard methods of analysis. The result of the study showed, *M. rume* had negative allometric growth patterns from both Lake and River with a growth exponent (b) value of 1.7966 and 2.2108 respectively. The mean condition factor, (K) for *M. rume* in Lake (1.99) and River (1.02), showed the fish is in good conditions. Dissolve oxygen (5.1mg/l) in the month March, in River is within WHO acceptable range while none is within the range in Lake, pH (5.91) in the month of June in Lake is below acceptable range and April (8.70), March (8.17), February (8.22), January (8.11) in River were above the WHO acceptable range, Turbidity in August (500mg/l), is the only month in River that is within the acceptable range, no month is within the WHO acceptable range for Alkalinity and Ammonia in Lake and River.

Key words: Kainji Lake, River Rima, Length, Weight, Condition Factor, Physico-chemical parameters.

Introduction

The length - weight relationship (LWR) is a useful tool in fishery assessment, which helps in predicting weight from length required in yield assessment (Garcia *et al.*, 1998). The relationship between the length (L) and weight (W) of a fish is usually expressed by the equation $W = aL^b$, where a represents the intercept and b (allometry coefficient) that provide information on fish growth. When $b = 3$, increase in weight is isometric (Anderson and Neumann, 1996). Condition factor, which is represented by K is an index reflecting interactions between biotic and abiotic factors in the physiological condition of fish. It is generically described as the well-being or robustness of an individual fish (Blackwell *et al.*, 2000).

Physico-chemical characteristics are highly important with regard to the occurrence and abundance of species. Discharge of urban, industrial and agricultural wastes has increased the quantity of various chemicals, which enters receiving water, altering considerably their physico-chemical characteristics. Nutrients like phosphorous and nitrogen from the domestic wastes and fertilizers accelerate the process of eutrophication (Koorosh Jalilzadeh *et al.*, 2009). Natural factors like dust, storm, runoff and weathering of minerals are slow processes in causing eutrophication (Kudari, *et al.*, 2006).

Materials and Methods

Kainji Lake

Kainji Lake is the largest man-made lake in Nigeria and it was created in 1968 after the damming of River Niger for electricity generation (FAO, 2017). The Lake lies between Latitude 9° 50' and 10° 55'N, Longitudes 4° 25' and 4° 45'E and between the borders of Sub-Saharan and Northern Guinea Savannah zones (Eli, 2007). It has a maximum length of 134 km and width of 24.1km, mean and maximum depth of 11m and 60m respectively, surface area of 1270km², a volume of 13.97km³, annual draw down of water level of 10-11m and catchment's area of 1.6x106km² (Eli, 2007; FAO, 2017). At full volume, the water level may reach an altitude of 142m above sea level. The lowest water level is reached in August at the peak of the rainy season, while the lake fills to variable high water peaks between September and March before next rains (Abiodun, 2002).

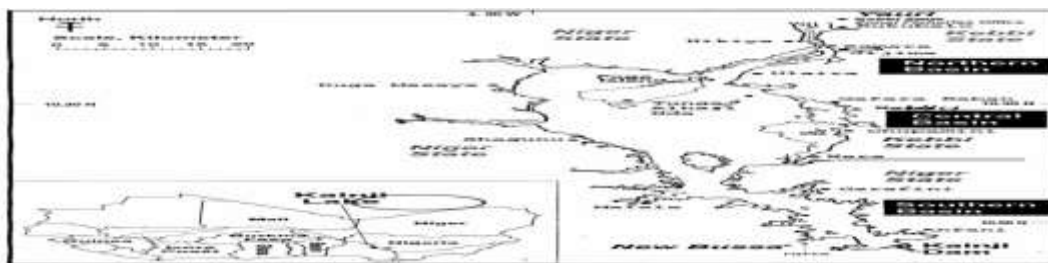


Figure 1: Map of Kainji Lake (Source NIFFR, Annual Report 2011)

River Rima

The region of River Rima (Figure 3.2) where sampled were carried out is at Kwalkwalawa/Dundaye area located on Latitude 13° 5'N and Longitude 5° 12'E along the road leading to Usmanu Danfodiyo University main campus (Hartenbach and Schuol, 2005). The vegetation of the river consists of grasses and trees e.g Acacia species; which is the dominant vegetation (Hartenbach and Schuol, 2005). Agricultural activities take place around the river, like rice farming e.t.c. (Hartenbach and Schuol, 2005). The river consists of wet land, and during wet season the river become flooded, direction of flow is from east to west (Hartenbach and Schuol, 2005).

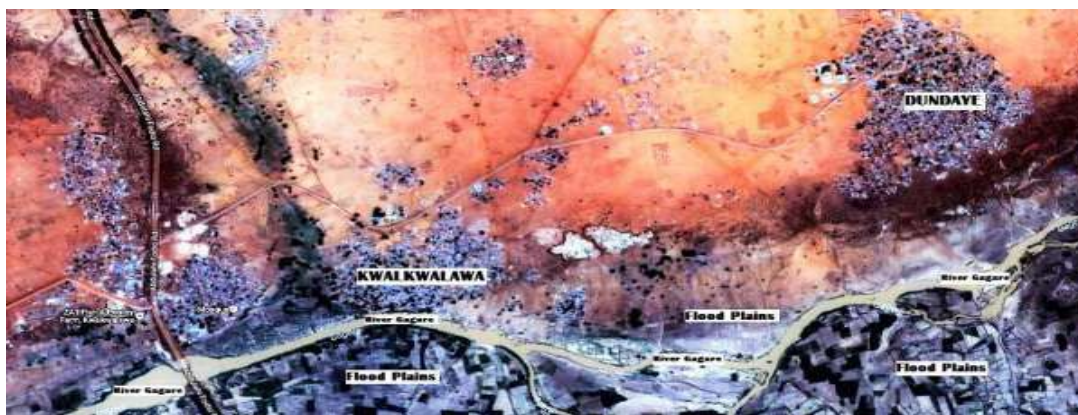


Figure 2: Map of River Rima (Source: Google Maps; www.maps.google.com)

Sample Collection and Measurement

One thousand and eight (1008) *M. rume* samples were collected; 531 from Kainji Lake and 477 from River Rima. About 50 samples were procured monthly from artisanal fishers and middlemen at landing sites on the lake and river. Samples were collected randomly to ensure range of sizes. The fishermen usually uses wide range of fishing gears such as, hook and line, long line, cast nets, gillnets and traps. From the catches, the fish were identified using checklist of Fish and Fisheries of Northern Nigeria book (Willian, 1967) and West Africa Freshwater Fish handbook (Holden and Reed, 1991).

Water Samples

Water samples were collected on monthly basis in plastic bottles having a one litre capacity; bottles were washed thoroughly with distilled water three times before use. Water samples were taken directly from the lake and river area at minimum depth of two to three feet. The samples collected were transported to Limnology Lab. at National Institute for Freshwater Fisheries Research New-Bussa. The physico-chemical analyses were conducted as described by APHA (2005), as follows

Temperature

Atmospheric temperature and surface water temperature of the Lake and River was determined using portable HANNA multi-parameter water tester (model HI 98129). Atmospheric temperature was initially taken before immersing the probes in water and this were then followed by water temperature with the probes in water. Atmospheric temperature and water temperature reading on the LCD dial screen were recorded on the spot.

Potential Hydrogen Ion (pH)

A portable HANNA multi-parameter water probe tester (model HI 98129) was used to test for the pH value of the Lake and River. The probe was inserted in water and reading displayed on the LCD dial screen was recorded, on the spot. For further test, the probe was rinsed in distilled water before use.

Turbidity

Turbidity was measured using Secchi disc. The Secchi disc with calibrated rope was used to obtain the degree of transparency of Lake and River. The disc was lowered into water, until it just disappears and the depth was recorded. Afterward the disc was then raised in water until it reappears; the depth at which it reappeared was recorded. The average of the two measurements was considered as the water turbidity. The unit of measurement is Nephelometric Turbidity Unit (NTU).

Dissolved Oxygen (DO)

Dissolved Oxygen was determined by Ethylene diamine tetra acetic acid (EDTA) titrimetric method, where 200 ml of the sample waters were measured in a conical flask and 1 ml of both manganese and azide solution was added into the conical flask. The solution was then shaken to get mixed thoroughly, where a milky or semi-turbid colour was obtained. The burettes were filled with a solution of sodium thiosulphate. The mixed solution of the sample water was decanted after settling (pouring away the upper part of the liquid) leaving the thick milky substance onto which was added 2 ml of Orthophosphoric acid as an indicator which turns the solution into a semi-yellowish colour. It was then titrated and values were recorded in mg/l at the turn of the solution to colourless (Ademoroti, 1996).

Ammonium

Fifty millimetres (50ml) of the water samples were measured using measuring cylinder, which were then transferred into a distillation flask. Magnesium Oxide (MgO) of 0.2g was added into the flask, and the flask was mounted on a distillation apparatus. Boric acid indicator of 10ml was placed into the conical flask under the condenser. The solution was placed into the condenser and distillation commenced. Distillate of 20ml was collected and titrated; distillate against 0.01M H₂SO₄ from green to pink colour at end point. Ammonium was calculated using the formula:

$$\text{NH}_4 \text{ (mg/l)} = \frac{\text{Titre value}}{\text{ml of sample}} \times 100$$

Alkalinity

Alkalinity of water was determined by Titrimetric method. A conical flask was taken and washed with distilled water then 25ml of water sample was taken and three to four drops of methyl orange was added. This was titrated against 0.02N H₂SO₄ until the colour of sample water changed from orange to blue. Note the reading directly from burette and used the same formula as for total hardness. This is measured in mg/l.

$$= \frac{\text{Std.Sol.Vol. used} \times \text{Std.Sol.Con.} \times \text{Molecular weight of CaCO}_3}{\text{Used sample water volume}} \times 100$$

Fish Measurement

The standard length (SL) of the fish was measured from the tip of the anterior part of the mouth to the end of caudal fin using measuring board. Fish were measured to the nearest centimeter. The weights were taken after blot drying with a piece of clean hand towel. Weighing was done with the aid of top loading balance (model OB-3000) to the nearest gram and recorded in data collection form.

Length - Weight Relationship (LWR)

The length and weight of *M. rume* from the two water bodies were measured in order to obtain the growth rate of the fish. The length-weight relationship was also determined using the following equation:

$$(1) W = aL^b \text{ ----- (Pauly, 1984)}$$

Where:

W = Body weight of fish in grams (g)

L = Total Length of fish in centimeters (cm)

a = regression constant

b = regression coefficient

The values of "a" and "b" were estimated from the logarithmic transformation of length and weight:

$$\text{Log } W = \log a + b \log L \text{ ----- Bagenal and Tesch, 1978)}$$

Where:

W = Weight of fish in grams (g)

L = Total Length of fish in centimeters (cm)

"a" and "b" are regression constant

3.2.4 Condition Factor (K) for *M. rume* was calculated using the equation below:

$$K = 100W/L^3 \text{----- (Pauly, 1984)}$$

K = the condition factor

L = Total length in centimeters (cm)

W = Weight in grams (g)

Data Analysis

Mean, Standard deviation, Percentage were computed using description statistic. Least Significant difference (LSD) and new Duncan Multiple Range Test (NDMRT) were carried out to rank means where necessary. The data collected were analyzed using SPSS package version 20.

Results

Monthly Length and Weight of *Mormyrus rume* in Kainji Lake and River Rima

The monthly length and weight of *Mormyrus rume* in Kanji and River Rima is shown on table 1. There were variations in these parameters across months during the period of study. The fish weight and length was highest in Kainji Lake in the months of July with percentage of (12.28%) and (12.40%) and lowest in January and December with percentage of (5.21%) and (5.91%) while River Rima has highest weight and length in June with percentage of (12.31%) and (10.32%) and lowest in November and December with percentage of (3.79%) and (5.76%) respectively.

Table 1: Monthly Length-Weight of *M. rume* in Kainji Lake and River Rima

Months	Number		Weight		Length	
	Kainji	Rima	Kainji	Rima	Kainji	Rima
Jan	38(7.16%)	41(8.60%)	5560(5.21%)	5264(9.03%)	14.63(6.09%)	12.84(8.86%)
Feb	33(6.21%)	26(5.45%)	6575(6.16%)	2964(5.09%)	19.90(8.28%)	11.40(7.87%)
Mar	50(9.42%)	39(8.18%)	8750(8.20%)	4891(8.39%)	17.50(7.28%)	12.54(8.66%)
Apr	50(9.42%)	40(8.39%)	11003(10.31%)	5456(9.36%)	22.00(9.16%)	13.64(9.42%)
May	49(9.23%)	44(9.22%)	12195(11.42%)	6431(11.04%)	24.90(10.36%)	14.62(10.09%)
Jun	48(9.04%)	48(10.06%)	10365(9.71%)	7175(12.31%)	21.60(8.99%)	14.95(10.32%)
Jul	44(8.29%)	39(8.18%)	13110(12.28%)	5152(8.84%)	29.80(12.40%)	13.21(9.12%)
Aug	49(9.23%)	50(10.48%)	10645(9.97%)	6543(11.23%)	21.70(9.03%)	13.01(8.98%)
Sep	41(7.72%)	38(7.97%)	6303(5.90%)	4139(7.10%)	15.40(6.41%)	10.90(7.52%)
Oct	38(7.16%)	38(7.97%)	8738(8.18%)	3879(6.66%)	23.00(9.57%)	10.21(7.05%)
Nov	41(7.72%)	24(5.03%)	6407(6.00%)	2207(3.79%)	15.63(6.51%)	9.20(6.35%)
Dec	50(9.42%)	50(10.48%)	7110(6.66%)	4169(7.15%)	14.20(5.91%)	8.34(5.76%)
Total	531(100%)	477(100%)	106761(100%)	58270(100%)	240.26(100%)	144.86 (100)

The Scatter Diagram of the Length-Weight Relationship of *Mormyrus rume* in Kainji Lake and River

The scattered plots of length-weight relationship of *M. rume* from the lake and river reflect the exponential increase of weight with increase in length (Figures 3 and 4). *Mormyrus rume* exhibited negative allometric growth with b-values less than 3, Kainji Lake ($b = 1.7966$) and River Rima ($b = 2.2108$). There was positive correlation between length and weight of the fish in both Kainji Lake ($r = 0.8780$) and River Rima ($r = 0.9573$).

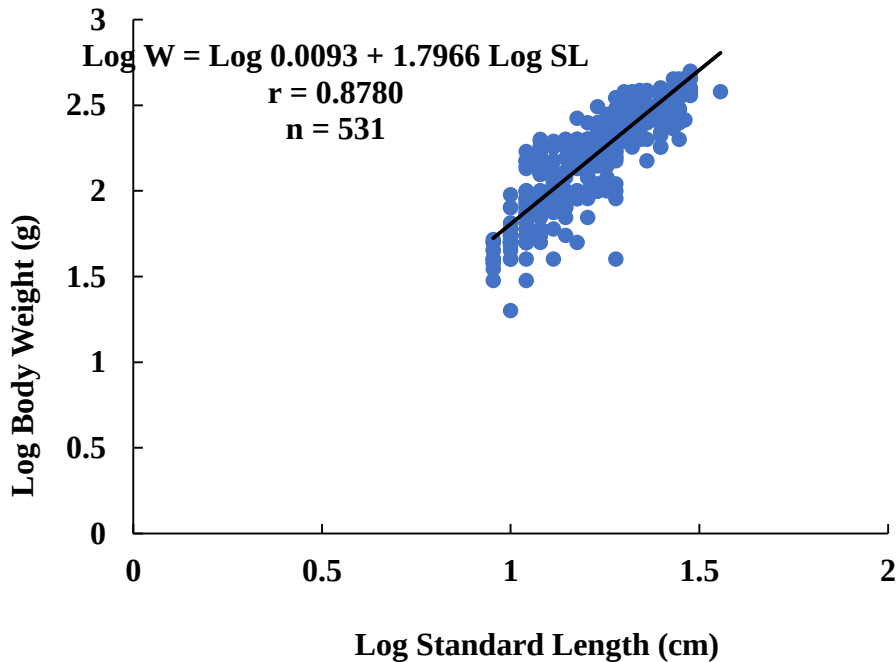


Figure 3: Log Standard Length - Weight of *M. rume* in Kainji Lake

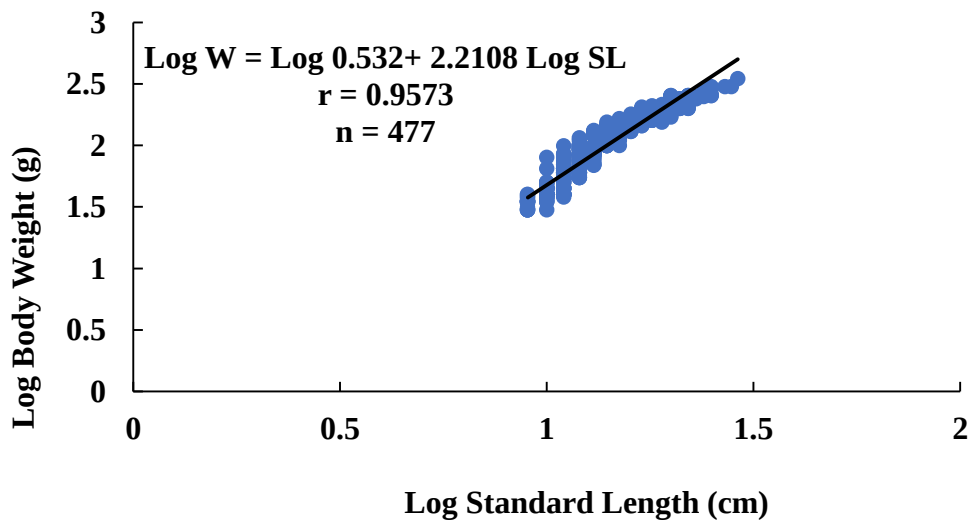


Figure 4: Log Standard Length - Weight of *M. rume* in River Rima

Condition Factor of *Mormyrus rume* in Kainji Lake and Rima River

The mean monthly variation in condition factor revealed that Kainji Lake recorded higher condition factor (Figure 5) in October and River Rima recorded in January. Similar condition factor was recorded for these water bodies in August, Kainji Lake and Rima River recorded lower condition factor in February and November respectively.

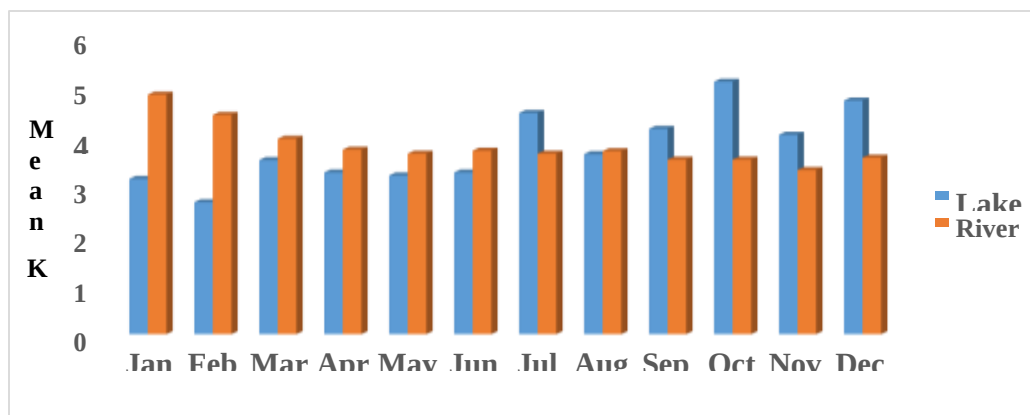


Figure 5: Mean Monthly Condition Factor (K) of *M. rume* in Kainji Lake and River Rima

Monthly Mean Values of Physico-chemical Parameters of Kainji Lake and River Rima

Table 2: shows monthly physico-chemical parameters recorded during the period of study. The highest temperature (32.12⁰C) was recorded in April for lake and in August (32.02⁰C) for river, while lowest temperature (25.05⁰C) was recorded in December for lake and river recorded the lowest temperature (24.07⁰C) in December. Lake recorded highest dissolved oxygen (8.22mg/l) in August while river recorded such (6.24mg/l) in May; lowest (1.24mg/l) in May for lake and October (2.70mg/l) for river. The highest pH (7.13) was recorded in February for lake and April (8.70) for river, while lowest pH (5.91) was recorded in June for lake and lowest (6.36) in August for river. Highest turbidity (290NTU) was recorded in August for lake, highest (500NTU) in August for river, while lowest turbidity (91NTU) was recorded in March for lake and February (185NTU) for river. Alkalinity in lake was highest (85.00mg/l) in December while river recorded highest (72.01mg/l) in May with lowest value (50.01mg/l) in January for lake and July (58.12mg/l) for river. Lake recorded highest Ammonia (0.52mg/l) in October, river has highest Ammonia (1.01mg/l) in April while lake had lowest Ammonia in May and June each with 0.47mg/l while river has lowest Ammonia (0.69mg/l) in October.

Table 2: Monthly Mean Values of Physico-chemical Parameters of Kainji Lake and River Rima

Month	Temperature (°C)		DO (mg/l)		pH		Turbidity (NTU)		Alkalinity (mg/l)		Ammonia (mg/l)	
	Kainji	Rima	Kainji	Rima	Kainji	Rima	Kainji	Rima	Kainji	Rima	Kainji	Rima
Jan.	28.21	25.04	5.22	2.71	6.18	8.11	100	200	50.01	71.00	0.50	0.82
Feb.	30.02	26.02	4.80	4.45	7.13	8.22	105	185	65.00	70.15	0.49	0.79
March	31.22	28.22	3.11	5.1	6.82	8.17	91	191	80.02	68.07	0.49	0.85
April	32.12	29.20	2.33	5.8	7.12	8.70	95	190	83.04	70.00	0.48	1.01
May	31.28	29.28	1.24	6.24	6.00	7.31	100	191	70.10	72.01	0.47	1.00
June	30.01	30.01	3.42	5.22	5.91	7.75	145	220	65.07	69.08	0.47	0.98
July	32.01	29.27	4.70	4.12	6.98	6.98	250	300	73.01	58.12	0.49	0.72
August	32.02	32.02	8.22	3.22	6.36	6.36	290	500	81.02	59.16	0.51	0.69
Sept.	31.01	31.01	6.34	4.13	6.95	6.95	225	451	80.04	65.05	0.50	0.70

Oct.	28.01	28.01	4.70	2.70	7.06	7.25	210	408	78.14	70.00	0.52	0.78
Nov.	27.02	26.03	2.15	2.85	6.17	7.08	185	350	80.16	69.15	0.50	0.85
Dec.	25.05	24.07	5.55	2.87	6.34	7.22	190	380	85.00	71.12	0.51	0.82
WHO				5.0	6.5-8.5				500	200		0.3

Key: DO = Dissolve Oxygen, WHO = World Health Organization, NTU = Turbidity

Discussion

Length-Weight relationship and condition factor of *Mormyrus rume*

The length-weight data obtained from this study showed different b-values for lake and river. The values obtained for lake (1.7966) and river (2.2108) indicated negative allometric growth pattern for *M. rume*. This implies that the fish become thinner with increasing length. This is similar to the findings of (Lawson and Jimoh, 2010) from Lagos lagoon and (Asuquo *et al.*, 2015) on the *M. rume* from Cross River estuary.

The mean condition (K) of *M. rume* in lake and that of the river indicated that the fish is in good condition because the values for lake (1.99) and river (1.02) are above 1 (unity). However, the conduciveness of the lake for the survival of the fish is better than the river. This could be due to food abundance, adaptation to the environment and fishing activities. (Hyslop, 1980) reported that condition factor may be affected by changes in season in relation to sexual differences, nutritional condition, stage of gonads maturity and age. This could also be reasons for such observation in this study.

Physico-Chemical Parameters of Kainji Lake and Rima River

The highest temperature (32.12°C) was recorded in April for lake while that of river (32.02°C) was in August with lowest in December for both water bodies even though lake was higher (25.05°C) than river (24.07°C). This could be due to the effect of rainfall, which makes the weather warm thereby affecting the water temperature. This is in line with the findings of (Boyd and Frobish, 1997) that reported tropical climate as having high water temperature all year round. The highest dissolved oxygen (8.22mg/l) recorded in the lake in August and May (6.24mg/l) for river with lowest (1.24mg/l) in May for lake and October (2.70mg/l) in October could be due to differences in the level and frequency of agitation rate caused by wind and biological activities in these water bodies. This supports the findings of Ibe (1993) that reported amount of dissolved oxygen in water as not constant but fluctuates, depending on temperature, depth, wind and amount of biological activities such as degradation.

The highest pH (7.13) recorded for lake in February and river (8.70) in April with lowest (5.91) in June for lake while in August (6.36) for river could be as result of increased in water level due rains and rate of water flow. The highest turbidity values recorded in both August for lake (290mg/l) and river (500mg/l) and lowest (91mg/l) in March for lake and February for river (185mg/l) could be due to floating materials such as fine silt carried by rainwater, into these water bodies, although higher in the river.

Alkalinity, which was highest (85.00mg/l) in December for lake and May in river (72.01mg/l), lowest (50.01mg/l) in January for lake and July for river (58.12mg/l) could be due to difference in human activities, the types of rocks and soil. Ammonia recorded highest (0.52mg/l) in October for lake while that of river (1.01mg/l) in April, lowest (0.47mg/l) in May/June for lake and river in August (0.69mg/l) could be due to intensive farming activities such as irrigation around the river.

Conclusion

Mormyrus rume exhibited negative allometric growth patterns in the lake and river. There were variations in monthly condition (K), which were still favourable for the survival of *M. rume* in both water bodies even though more favourable in lake. Monthly physico-chemical parameters fluctuated in both water bodies with higher temperature, dissolved oxygen and alkalinity recorded in lake, while pH, ammonia and turbidity were higher in river.

Reference

- Abiodun, J.A. (2002). Evaluation of Fisheries Catch trend on Lake Kainji in Nigeria from 1995-2001. *Journal of Applied Sciences and Environmental Management*, 7 (2).
- Ademoroti, L. M. A. (1996). *Environment Chemistry and Toxicology*. Foluelex Press Ltd., Ibadan, pp: 217.
- Anderson, O.R. and Neumann, R. M. (1996). *Length-weight and associated structural indices*. In Nielsen, L. A., Johnson, D. L. (Eds.) Fisheries techniques.
- APHA. (2005). *Standard methods for the examination of water and wastewater*, 21st Edition. Amer. Publ. Heal. Assoc., Amer. Water Works Assoc. and Water Poll. Contr. Fed., Washington D.C. 15th Ed. p.107. Bethesda, American Fish Society. 447- 482.
- Asuquo, P. E., Eyo, V. O. and Ikechukwu, C. C. (2015). Feeding ecology, Length-weight relationship and condition factor of *Mugil cephalus* (Pisces: Mugilidae, Linnaeus, 1758) from Cross River Estuary, Nigeria. *European Academic Research*, 11(12):1527615294.
- Bagenal, T. B. and Tesch, F. W. (1978). Age and growth. In *Methods for Assessment of Fish Production in Fresh Waters*. 3rd ed., edited by Bagenal, T.B. Oxford: Blackwell Scientific Publications. pp. 101-136.
- Blackwell, B. G., Brown. M. L. and Willis, D. W. (2000) Relative weight (Wr) status and current use in fisheries assessment and management. *Reviews in Fisheries Science*, 8:1- 44.
- Eli (2007) List of fresh water fishes of Nigeria. Accessed 11/01/2017.
- FAO, (2017) Fish species diversity in rivers, lakes, and reservoirs of Nigeria. www.fao.org/docrep/005/T1230E04.htm.
- Garcia, C. B., Duarte. J. O., Sandoval, N., Von Schiller, D., Melo, G. and Navajas, P. (1998). Length-weight relationships of demersal fishes from the Gulf of Salamanca, Colombia, Naga. *ICLARM Quart.* 21(3):30-32.
- Holden, M. J. and Reed, W. (1991). *West African freshwater fish*. Longman, London. <https://www.google.com/maps/place/15.45>.
- Hyslop, E. J. (1980). Stomach content analysis; A review of methods and their Application. *J. Fish Biol.* 17; 411-429.
- Ibe, P. A. (1993). A General review of pollution dynamics of aquatic macro invertebrates of tropical fresh water system. Unpublished MSc. Thesis, University of Jos Nigeria 88pp.
- Kudari, V. A., Kanamadi, R. D., and Kadavaram, G. G., (2006). Limnological studies of atteveri and Bachanki reservoirs of Uttar Kannada District, Karnataka, India. *Eco. Env. Cons.* 12(1), 87-92.
- Lawson, E. O. and Jimoh, A. A. (2010). Aspect of the biology of grey mullet, *Mugil cephalus*, in Lagos lagoon, *Nigeria AACL Bioflux.* 3(3):181-193.
- Pauly, D. (1984). Fish population dynamics in tropical waters: a manual for use with programmable calculators, *ICLARM Studies and Reviews* 8, 325.

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Length-Weight Relationship and Condition Factor of *Brycinus nurse* in the New Calabar River, Niger Delta, Nigeria

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Abstract

Length-weight and condition factor of *Brycinus nurse* from New Calabar River were investigated. The 401 specimens (average length 11.80 ± 1.59 cm and weight 20.63 ± 8.3 g) were monthly sampled from fishermen between February 2020 and January 2021. Length weight relationship was computed using the equation $W = aL^b$, which was further transformed into $\log W = \log a + b \log L$ while the condition factor was determined using the equation: $K = 100 (W / L^3)$. The length weight relationship revealed an exponent 'b' value of 2.43, showing a negative allometric growth. The condition factor ranged from 1.09 to 1.42 indicating the robustness of the fish in New Calabar River.

Keywords: Length-weight, Allometry, Condition factor, New Calabar River.

Introduction

Brycinus nurse (Ruppell, 1832), commonly referred to as nurse tetra is a pelagic, potamodromous ray-finned fish species belonging to the family Alestidae (Reide, 2004). It inhabits rivers, lakes, irrigation canals and fringing vegetation. *Brycinus nurse* is widely distributed in West Africa, in lower Guinea present in Cross and Mémé rivers. Also, in Chad basin and Nile River (Getahun, 2007). *Brycinus nurse* is easily identified by Bright red tail fin, other fins are tinged with red, and there is a black patch on the tail peduncle (Adesulu & Sydenham, 2007). This species is said to be of commercial importance due to the fact that they are widely consumed locally and have food value (Saliu & Fagade, 2004). But it is classified as least concern species in worldwide (IUCN, 2021).

The study of length-weight relationship is of paramount importance in fishery science, as it assists in understanding the general well-being and growth patterns in a fish population. Length-weight relationship is of great importance in fishery assessments (Haimovici & Velasco, 2000). The length-weight relationship provides means for finding out the condition factors, which indicate the "wellbeing of the fish" (Olopade *et al.*, 2018). The relationship between length and weight (LWR) along with condition factors are useful parameters for assessing the well-being of individuals and to determine probable variations among different stocks of the same species (King, 2007). Condition factor is calculated from the relationship between the weight of a fish and its length, with the intention of describing the "condition" of that individual fish (Froese, 2006). This study was therefore designed to investigate biological information such as, growth pattern and condition factor of *Brycinus nurse* in the New Calabar River, Niger Delta, Nigeria.

Materials and Methods

The New Calabar River lies between longitude $006^{\circ}53' 53.086''$ E and latitude $04^{\circ}53' 19.020''$ N in Choba, Rivers State, Nigeria. The entire river course is situated between longitude $7^{\circ}60''$ E and latitude $5^{\circ}45''$ N in the coastal area of the Niger Delta and empties into the Atlantic Ocean. The New Calabar River region has an annual rainfall between 2000- 3000 mm (Abowei 2000). The New Calabar River is among the important water resources in the Niger Delta region of Southern Nigeria; it is in the vicinity of the rapidly expanding oil city of Port Harcourt in Rivers State, Southern Nigeria. (Dienye & Woke, 2015).



Figure 1: Map showing the sampling Stations

Sampling was done twice a month from February 2020 to January 2021 in two sampling stations with the assistance of local artisanal fishers. The fish species was identified using fish identification keys (Adesulu & Sydenham, 2007). Measurements were taken at the landing sites: total length (TL) and the body weight (BW) of individuals of the species using a measuring board of 30cm ruler (for lengths) and an electronic sensitive scale model Ja5003n 500g/1mg/0.001g (for weight). Length-weight relationship was computed using the equation: Length-weight relationship ($W = aL^b$) where, W = weight of fish in grams (g), L = length of fish in centimeters (cm), a = Regression constant which describes the rate of change of weight with length (intercept), b = Regression coefficient which is the weight at unit length (slope). The equation (1) was transformed to log to estimate the parameters 'a' and 'b' (Nehemiah *et al.*, 2012) as shown;

$$\log W = \log a + b \log L \quad (2)$$

The condition factor ($K = 100 \, w/L^b$) (3) where W = weight of the fish in gram (g), L = total length in centimeters (cm), b = value obtained from the length weight relationship.

Results and Discussion

The total length of the *Brycinus nurse* ranged from 8.9 - 16.8cm with a mean of 11.80 ± 1.59 cm and the total weight between 10 - 55.2 g with a mean of 20.63 ± 8.38 g as shown in Table 1. The exponent b value was found to be 2.439. (Figure 2). The value of correlation coefficient (r^2) estimated for the species was 0.8193 (table 1), which shows that the relationship between length and weight of the fish was highly significant.

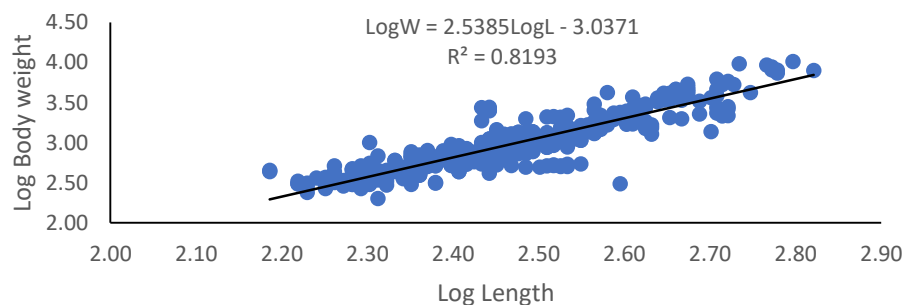


Figure 2: Length-weight relationship of *B. nurse* during the study period

The length weight relationship of this study revealed that *Brycinus nurse* had an exponent "b" value of 2.539, which shows a negative allometric growth; the value however, fall within the acceptable range of 2.5 and 3.5, which is typical for tropical fish stocks (Froese, 2006). A similar observation was also reported in *B. nurse* from the mid Cross River basin by Iyabo (2014), with a "b" value of 2.425. The b value of 2.958 was recorded by Lalèyè (2006) from the Ouémé River in Bénin. Dankwa (2003) recorded 2.959 for the exponent "b" in Volta Lake Ghana; these are in contrast with the findings of this study as they exhibit closely isometric growth. While Getahun (2007) recorded the b value of 3.086 in River Bia; Abobi & Ekau (2013) reported a b value of 3.0737 in *B. nurse* from the White

Volta River in Ghana; and Olopade *et al.* (2019) recorded a b value of 3.5405 in the New Calabar River, all showing a positive allometric growth. The differences in these findings may be due to several factors that affect the growth of fish, which may include; habitat, seasonal variation, sexual dimorphism, gonadal maturation, availability of food and general health of the fish (Ozcan & Balik, 2009). The condition factor (K) of *Brycinus nurse* in this study was in the range of 1.09 - 1.42 indicating that the population is in good growth condition as the value is greater than 1. K values greater than 1 implies that the fishes thrive well in their current habitat (Komolafe and Arawomo, 2011). According to Ikomi&Sikoki (2001), the K value for *B. nurse* in the River Jamies on, Nigeria ranged from 2.33 to 2.65 with respect to size variations, mean K values decreased with an increase in the fish size within the range of 7-11 cm, but thereafter the K values increased with additional size.

Table 1: Length, weight and condition factor of *B. nurse* in New Calabar River

Species	TL		Weight					K	
	Mean	Range	Mean	Range	a	b	r ²	Mean	Range
<i>Brycinus nurse</i>	11.80±1.59	8.9 - 16.8	20.63±8.38	10 - 55.2	- 3.03 7	2.539	0.81 9	1.22±0.20	1.09 - 1.42

Conclusion

The size of *B. nurse* (8.9 - 16.8cm) recorded in this study indicated that most individuals were relatively small sizes to medium, and were not allowed to grow to adults as a result of unregulated fishing methods. This information will help in the development of efficient management strategies of the species and further studies of population dynamics and stock assessment in the New Calabar River.

References

- Abowei, J. F. N. (2000). Aspect of the fisheries of the lower Nun River. University of Port Harcourt, Nigeria
- Abobi, S. M., & Ekau, W. (2013). Length-weight relationships and condition factors of *Alestes baremoze*, *Brycinus nurse* and *Schilbe intermedius* from the lower reaches of White Volta River (Yapei), Ghana.
- Adesulu, E. A. Sydenham D.H.J (2007). The freshwater fishes and fisheries of Nigeria. Macmillan Nigeria Publishers Limited.
- Bailey, R. G. (1994). Guide to the fishes of the River Nile in the Republic of the Sudan. *Journal of Natural History*, 28(4), 937-970.
- Dankwa, H.R. (2003). Traditional knowledge of freshwater fishes in some fishing communities in Ghana. *ACP-EU Fisheries Research Report*, 14, 223-229.
- Dienye H.E, & Woke G.N (2015) Physico-chemical Parameters of the Upper and Lower Reach of the New Calabar River Niger Delta. *J Fisheries Livest Prod* 3:154. Dol:10.4172/2332-2608. 1000154.
- Froese, R. (2006). Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. *Journal of applied ichthyology*, 22(4), 241-253.
- IUCN, (2021). The IUCN red list of threatened species. Version 2021-1. Accessed on 10 September 2021. <https://www.iucnredlist.org>
- King, M., (2007). Fisheries biology, assessment and management, 2nd Edition. Blackwell Scientific Publications, Oxford, pp. 381.
- Komolafe, O. O., & Arawomo, G. A. O. (2011). Observations on the Composition, Physiological Condition and Fisheries in Erinle Lake, Osun State, Nigeria. *West African Journal of Applied Ecology*, 18, 71-78.
- Nehemiah, A., Maganira, J. D., & Rumisha, C. (2012). Length-Weight relationship and condition factor of tilapia species grown in marine and fresh water ponds. *Agriculture and Biology Journal of North America*, 3(3), 117-124.
- Olopade, O. A., Dienye, H. E., & Nworgu, U. C. (2019). Estimation of growth, mortality, and exploitation status of nurse tetra (*Brycinus nurse*) and true big scale tetra (*Brycinus macrolepidotus*) (Family: Alestidae) from the New Calabar River, Nigeria. *Indonesian Fisheries Research Journal*, 25(2), 113-122.
- Olopade, O.A., Dienye, H.E., Jimba, B., Bamidele, N.A. & Taiwo, I.O., (2018). Length-weight relationship and condition factor of Guinean Tilapia *Coptodon guineensis* (Günther, 1862) from the New Calabar River and Buguma Creek, Nigeria. *Punjab Univ. J. Zool.*, 33(1): 42-46.
- Ozcan, G. & Balik, S. (2009). Some biological parameters of the bergamae barb, *Capoeta bergamae* Karaman, 1969 (Cyprinidae) in Kemer reservoir, Aydin, Turkey. *North-Western Journal of Zoology*, 5(2), 242-250.

- Riede, K. (2004). Global register of migratory species: from global to regional scales: final report of the R&D-Projekt 808 05 081. Federal Agency for Nature Conservation.
- Saliu, J. K., &Fagade, S. O. (2004). The Structural and Functional Morphology of the Hard Parts of Brycinus nurse (Pisces: Cypriniformes, Characidae), From Asa Reservoir, Ilorin, Nigeria. *Turkish Journal of Fisheries and Aquatic Sciences*, 4(1), 23-3

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Spatial Distribution and Diversity of Macrobenthos in Relation to Physico Chemical Parameters in the Lagos Lagoon

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Abstract

The spatial distribution and diversity of macrobenthos in relation to physico-chemical parameters in the Lagos Lagoon was investigated from May 2019 to April 2021. A total of 795 benthic macro-invertebrates belonging to 3 phyla, Mollusca, Arthropoda and Annelida were collected from 3 stations in the Lagoon. The phylum Mollusca dominated with 77.73% and the least was Decapods with 4%. All the stations studied had relatively low species diversity. The Shannon-Wiener index of diversity (H) ranges from 2.21 to 2.405, Margalef index (d) ranges from 1.782 to 2.16. Evenness index also varied from 0.75 to 0.85. The physico-chemical parameters of the water were significantly correlated (< 0.005). The overall macrobenthos diversity studied in the Lagos Lagoon was relatively low. The low diversity recorded from this study can be attributed to the influence of anthropogenic activities on the species distribution, diversity and abundance.

Keywords: Species diversity, Macrobenthos, Coastal environment.

Introduction

Benthos include several species of organisms which cut across different phyla, they include; arthropods, molluscs, annelids, etc. these group of organisms play a vital role in the circulation and recirculation of nutrients in aquatic ecosystems (Kolawole-Daniels, 2015). They are bottom dwellers and serve as food for fishes in most aquatic environment. Bottom sediment habitats cover most of the coastal environments and as such support a diverse array of macrobenthic communities that play important roles in ecosystem processes such as recycling nutrients, detoxifying pollutants, dispersion and burial, and secondary production (Bassey *et al.*, 2020). Benthic macroinvertebrate community is widely used for detection and monitoring of man's impact on aquatic ecosystems. Several research work have been done on macrobenthos community of the Lagos Lagoon. They include Ajao and Fagade (1990) A study of the sediments and communities in La gos Lagoon, Brown and Ajao (2004) Effects of topographical modification on the composition and abundance of macro-fauna in southern Lagos Lagoon, Edokpayi and Nkworji (2007) also worked on the physico – chemical and macrobenthic invertebrate characteristics of a sewage dumpsite on the western part of the Lagos lagoon and recorded high abundance of the polychaete *Capitella capitata*. Therefore, this study aims to explore and understand the current spatial distribution and diversity of macrobenthic communities in Lagos Lagoon.

Materials and Methods

The Lagos lagoon is a part of a continuous system of lagoons and creeks found along the coast of the south-western part of Nigeria from the border within the republic of Benin to Ondo state. The lagoon is bordered by the forest belt and receives input from a number of important large rivers, (Ajao, 1996). The lagoon is located between latitude 6°26' and 6°38' N longitude 3°23' and 3°43' E. the lagoon covers an area of about 208km², it is generally between 0.5 – 2m deep. The lagoon extends from the coast at Lagos to about 37km north and 48km east where it narrows and continues as the Lekki lagoon. The estimated area of the main body is 150.56km.

Table 1: Study stations and coordinates.

Station	GPS coordinates	
	(N)	(E)
Osbourne)	06°27'36.2	003°28'02.3
(Ajah)	06°30'23.1	003°34'15.8
Makoko)	06°28'45.5	003°23'36.0

Collection of Samples

At each sampling station, two replicate samples of benthic sediments were collected monthly from May 2019 to April 2021 using a 0.1m² Van Veen grab from a motorized boat, the sediment collected were sieved through a 0.5mm mesh sieve. The residue collected were poured in plastic containers and preserved immediately using 10% formalin to which Rose Bengal stain was added, labeled and later transported to the marine biology laboratory for further examination. In the laboratory, each sediment sample was washed through 0.5mm and 0.2 mm mesh size sieve. The macrobenthos retained were poured into a white enamel tray and sorted out into their various groups using forceps and hand lens. Further Identification was done with the aid of Pennak 1978, Edmunds, 1978. Macrobenthos diversity was estimated using Shannon- wiener index of diversity (H) Shannon and Weaver (1963). The species richness was determined using Margalef's index, (Valiela, 1995) and Evenness index (E).

Measurement of Physico-Chemical Characteristics

Mercury in-glass thermometer was used to determine the water and air temperature. Dissolved oxygen, Biological oxygen demand, conductivity, total dissolved solid, Salinity and turbidity were determined using a digital multimeter probe (Oakton™). While transparency was measured using a meter rule and depth was measured using a depth finder device.

Statistical Analyses

Diversity indices such as Margalef's index for species richness, Shannon-Wiener and Simpson's indices for species diversity, and the Equitability index for evenness of the benthic macro invertebrates were estimated using PAST 4.03, the variations in physicochemical parameters between stations and sampling periods were analyzed using ANOVA. Pearson's correlation coefficient and Principal component analysis were also used to show the relatedness between the species and the environmental variables.

Results and discussions

The mean variation of the Physico-chemical characteristics of the water samples in the three sampled stations is shown in Table 2. The analysis of variance (ANOVA) showed significant differences. The analysis of variance (ANOVA) showed significant differences ($p < 0.05$) across the stations in dissolved oxygen and pH. Other parameters varied across the three stations but there was no significant difference. Dissolved Oxygen which is one of the most important parameters when assessing water quality, it helps in regulating the distribution, abundance and diversity of macrobenthic fauna and flora (Yogendra&Puttaiah, 2008). The lowest mean DO value of 2.79 ± 0.12 mg/l was observed in Makoko in the month of August, generally, the dissolved oxygen was very low and fell below the permissible limit of 5.0mg/l for WHO/FMEnv throughout the sampled stations. It was lowest in station 3 (Makoko) and this could be due to the anthropogenic discharge containing high concentration of organic matter. The DO values of this study were similar to those reported by Nkwoji *et al.*, 2013, (Bassey *et al.*, 2020) 2.2 to 10.8 mg/L.

Species Composition, Abundance and Diversity of Benthic Macroinvertebrates in Lagos Lagoon

A total of 795 benthic macroinvertebrates belonging to 3 phyla and 5 classes were collected from three(3) stations in the Lagos Lagoon (Table 2). Mollusca, Arthropoda and Annelida were recorded. Mollusca was represented by gastropoda and bivalva; the phylum Annelida was represented by polychaete worms while Arthropoda was represented by Chironomid larva and Decapoda was represented by hermit crabs and *callinectes*. The percentage composition of different macrobenthic invertebrates is shown in Figure 2. The phylum Mollusca dominated with 77.73% and the least was decapods with 4%. This dominance of molluscs may be typical of brackish water benthos. The diversity indices distribution patterns are presented in Table 4.

Table 2: Mean variation of Physico-chemical parameters in the Lagos Lagoon.

Parameters (Mean±S.E)	STATIONS		
	Ajah	Osbourne	MakokoWHO/ FMEEnv
AIR_TEMP	30.5±0.60 ^a	29.85±0.58 ^a	28.56±1.61 ^a
MIN	26.7	26.1	12.2
MAX	33.5	33.2	33.3
WATER TEMP	28.43±0.57 ^a	28.57±0.46 ^a	28.79±0.59 ^a
MIN	23.7	24.9	25.5
MAX	31.3	31.4	31.5
DISSOLVED OXYGEN	4.89±0.22 ^b	4.73±0.19 ^b	3.81±0.12 ^a
MIN	3.89	4.02	2.79>6
MAX	6.3	5.87	4.49
SALINITY	4.34±1.07 ^a	1.74±0.80 ^a	5.72±1.94 ^a
MIN	0.59	0.02	0.01
MAX	10.9	8.22	21
TRANSPARENCY	0.87±0.16 ^a	6.17±4.48 ^a	0.553±0.06 ^a
MIN	0.4	0.3	0.25
MAX	2	5	0.88
pH	7.95±0.14 ^b	7.75±0.10 ^{ab}	7.32±0.23 ^b
MIN	6.95	7.32	4.84
MAX	8.55	8.45	7.85
TDS	2625±753 ^a	2640±1157 ^a	4539±1201 ^a
MIN	904	872	132
MAX	9889	10954	11892
CONDUCTIVITY	4009.5±1158 ^a	3804±1709 ^a	6630±1806 ^a
MIN	1266	117.2	186
MAX	1491	16350	17760

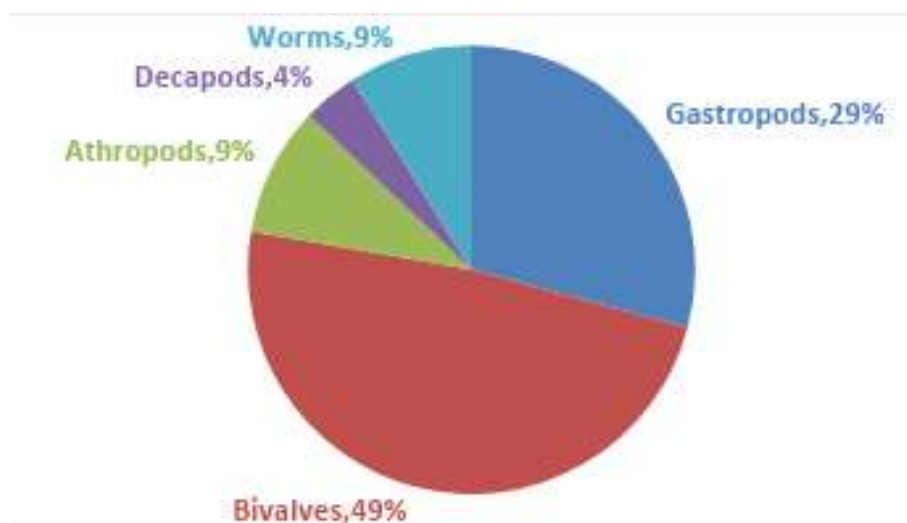
**Figure 1: Percentage composition of Phylum of macrobenthic invertebrate from Lagos Lagoon.**

Table 3: Composition and abundance of Macrobenthos from sampled stations in Lagos lagoon.

TAXA	AJAH	OSBOURNE	MAKOKO
GASTROPODS			
<i>Tympanostomysp</i>	3	30	9
<i>Melanoidessp</i>	25	8	5
<i>Thais sp</i>	27	7	*
<i>Pachymelaniasp</i>	23	14	14
<i>Neritinasp</i>	29	*	*
<i>Littorinasp</i>	9	*	29
BIVALVES			
<i>Crassostreagasar</i>	38	26	10
<i>Crassostreatulipa</i>		34	58
<i>Pitariumens</i>	28	16	32
<i>Tivelatripla</i>	45	7	*
<i>Pernaperna</i>	*	45	11
<i>Diplodontadiaphana</i>	*	30	6
ARTHROPODS			
Chironomids larva	43	21	6
Barnacle	4		*
DECAPODS			
<i>Callinectesamnicola</i>	*	12	*
Hermit crab	*	*	20
WORMS			
<i>Capitellacapitata</i>	*	12	15
<i>Nereissp</i>	*	*	44
Taxa (S)	11	13	13
Individuals (N)	274	262	259

Where S= total taxa, N= no. of species, *= no species represented.

Table 4: Diversity Indices of Benthic Macroinvertebrates across the sampled stations in Lagos Lagoon.

Diversity Index	Ajah	Osbourne	Makoko
Taxa	11	13	13
Individuals	274	262	259
Dominance_D	0.119	0.102	0.125
Simpson_1-D	0.881	0.898	0.875
Shannon_H	2.21	2.405	2.287
Evenness_e ^{H/S}	0.8289	0.8524	0.7577
Margalef	1.782	2.155	2.16
Equitability_J	0.9217	0.9377	0.8918

From the three stations sampled, the Macrobenthic assemblages on the Lagos Lagoon, Dominance index had highest of 0.125 in Makoko which reflects certain species which are pollution tolerant dominating the anthropogenic area. Generally, Simpson index ranges from 0 to 1, from this study, Simpson diversity ranged from 0.875 to 0.898. Usually, stable communities have high Simpson diversity value (0.6 to 0.9), while the communities under stress conditions, exhibiting low diversity and tend towards zero value, Dash (2003).

Shannon-Wiener diversity index varies from 2.21 to 2.405, this suggests a moderately polluted lagoon and the macro benthic community present are undergoing stress due to anthropogenic activities. According to this index, values less than 1 characterize heavily polluted conditions, and values within the range of 1 to 2 are moderately polluted while values above 3 indicate stable environmental conditions (Bassey *et al.*, 2020) Margalef diversity index ranged between 1.782 to 2.16. Evenness index also varied from 0.75 to 0.85 in Lagos Lagoon. The low diversity index recorded from this study can be attributed to the influence of anthropogenic activities on the species distribution, diversity and abundance.

Canonical correspondence Analysis

In the CCA analyses, which shows how environmental variables influence the species diversity, components 1 and 2 accounted for 90.68% variability among the samples (Figure 2). The Eigenvalues for TDS, salinity and conductivity were 0.85, 0.99 and 0.88 respectively. The PC 1 showed that conductivity, TDS and water temperature has significant impact on the species distribution, Margalef and dominance index while in transparency also influence the Simpson, Equitability, Evenness and Shannon Weiner diversity index of the benthic macroinvertebrate from the Lagos Lagoon. PC2 shows that Salinity, air temperature, dissolved oxygen and pH plays a major role in the species abundance (number of individuals) of the macrobenthic invertebrates in the lagoon.

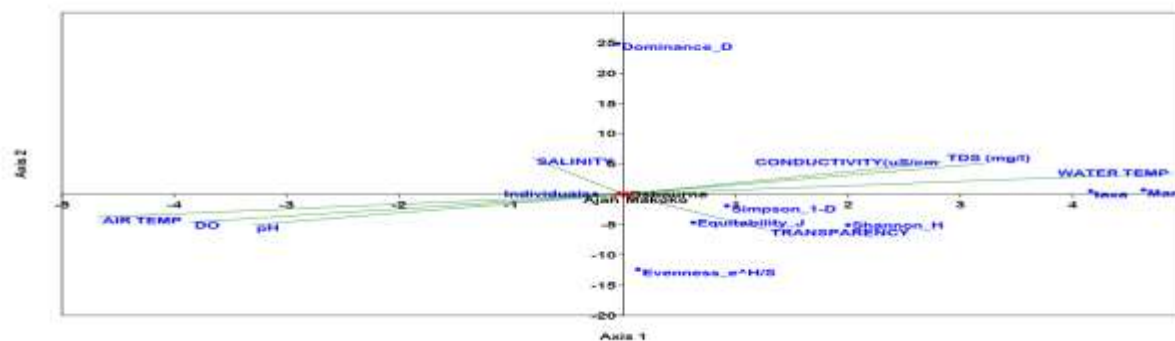


Figure 3: Canonical correspondence analysis of physico-chemical parameters and diversity indices of benthic macroinvertebrate of the Lagos Lagoon

Conclusion

This study contributes to knowledge on the influence of environmental variables on the diversity of macrobenthic invertebrate communities of the Lagos Lagoon. The results from this study showed that species composition and diversity were significantly influenced by environmental variables, hence the Lagos Lagoon is under anthropogenic pressure from both organic and inorganic pollutants.

References

- Ajao EA (1996). Review of the state of the pollution of the Lagos lagoon. Nigerian Institute of Oceanography and Marine Research (NIOMR) Technical Paper No. 106.
- Bassey BO, Nosazeogie EO, Abdullahi IM, Bello B, Abiodun O, Olapoju O, Ajani G, Igbo J, Balogun JK, Yakub AS. Diversity of Macrobenthic Invertebrates in Relations to Some Selected Water Quality Parameters in Lagos Lagoon, Nigeria. Biomed J Sci & Tech Res 30(1)-2020. BJSTR. MS.ID.004886.
- Dash MC (2003) Fundamental of Ecology. (2nd Edn.). Tata McGrawHill publishing company limited, New Delhi, India.
- Kolawole-Daniels, A.O. (2015). Composition and Abundance of Macrobenthos in the Lagos Lagoon *International Journal for Innovation Education and Research* www.ijer.net Vol:-3 No-8, pg 154-159.
- Nkwoji JA, Yakub A, Ajani GF, Balogun KJ, Renu KO, et al. (2010) Seasonal variations in water chemistry and benthic macroinvertebrates of a South Western Lagoon, Lagos, Nigeria. J AmerSci 6: 85-92.
- Nkwoji JA, Edokpayi CA (2013) Hydrochemistry and community structure of benthic macroinvertebrates of Lagos Lagoon, Nigeria. Res. J Pharm Biol Chem Sci 4 (1): 1119-1131.
- Pennak, R.W., (1978). Fresh Invertebrates of the United States. 2nd Edn. John Wiley and Sons, USA. pp803.

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Comparison of total hydrocarbon and heavy metal concentrations in four dominant crab species at Eagle Island, Niger Delta Nigeria

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Abstract

The terrestrial and aquatic life of crabs predispose them to heavy metal absorption and accumulation. This habit creates a transmission pathway up the food chain to the consuming population in coastal areas. It is thus predicted that increased in total hydrocarbon content and heavy metals in the body parts of crab will result to an increase in human contamination via crab meat. In this study four dominant crab species (*Ucatangeri*, *Goniopsis spelli*, *Callinectes amnicola* and *Sesarmaelegans*) were sampled in a sand filled mangrove forest at Eagle Island. In all ten samples each (n=40) were collected, butchered into parts, and sent to the laboratory for chemical analysis for cadmium (Cd), lead (Pb), zinc (Zn) and total hydrocarbon content (THC) using HACH DR 890 colorimeter (wavelength 420 nm) and microwave accelerated reaction system (MARS Xpress, North Carolina) respectively. There was significant difference ($P > 0.01$) in the interaction effect between metals and species and between metals and body parts of crabs. Zinc had the highest concentration followed by Pb, Cd and THC (i.e., $Zn > Pb > Cd > THC$) while for species the order of concentration is *U. tangeri* > *C. amnicola* > *S. elegans* > *Goniopsis spelli*. The result reveals that concentrations of Cd, Pb and THC were above the EU limit of 0.5mg/kg. Similarly, swimming crabs (*C. amnicola*), which is the species eaten was found to have the highest lead concentration (44.61 ± 7.34 mg/kg) making it unfit for consumption. Thus, there should be regular monitoring of metals in crabs in this locality to prevent further human contamination via food poisoning.

Introduction

Crabs are major ecosystem engineers in mangrove forest globally (Vu et al. 2017), this is because their burrowing activities influence soil chemical properties and ecosystem dynamics (Taylor, 2015). The burrows the crabs create in the soil allow the entry of oxygen during low tides and water during high tide. The mixing of the soil during burrowing helps to circulate soil nutrients around the forest from a region of high to low nutrient concentration (Li et al. 2021). During the process of feeding and burrowing, crabs inadvertently consume soil materials leading to increase in metallic contents of their body. Crabs also feed on plant parts, debris, and dead aquatic organisms (e.g., fingerlings) deposited by tidal currents on the forest floor. The feeding and burrowing behaviors of the crab species expose them to chemical contamination with some effect on the food chain (Karram and Al-Wazzan, 2021; Pinheiro et al. 2021). Several crab species are found in the mangrove forest of Eagle Island that are differentiated by size, color, burrowing habit, location, and general behavior. At Eagle Island the dominant species are the fiddler crabs (*Ucatangeri*) (Numbere, 2020a). These crabs are mostly found in the deforested areas of the mangrove forest dominated by fewer trees but more sand and swamp (Ghaem-Maghami and Naderloo, 20221). Fiddler crabs prefer areas that are devoid of forest canopies and exposed to the weather. The male fiddler crabs are larger than their female counterparts (Tina and Muramatsu, 2021). The males have a distinctly large and pronounced pincers that is used for digging burrows, courting females, and inviting tidal currents. This species is made up of combination of faded orange and black color.

The small marsh crabs (*Sesarmaelegans*) are the next dominant species that are often found in the grassy areas of the deforested mangrove forest. They create their burrows underneath the grassy soil, and feed on the grasses (Rocca et al. 2021). The grassy soil where the burrows are constructed is wet because it traps water during high tide and rainfall. This makes the environment to be humid and warm for the crabs. This crab species is fragile with tender outer covering and carapace structure and do not grow too big even at full maturity. The average length of the small size ranges between 1-3cm from side to side. They feed on insects and small organisms trapped inside the grass and mostly bask and swim in pool of water trapped within the grassy soil after each rainfall or surge in water current. Their carapace surface is rough and brownish black in color while the ventral region is light and whitish. They have short legs for walking and running. They construct small burrows that are often filled by water where they live and

transport food materials. This species is also exposed to pollutants that are trapped within the grassy and watery environment of their habitat.

These four crab species influence the ecosystem dynamics of the mangrove forest, and can be used as bio-indicators of pollution (Yanez-Rivera et al. 2019). Out of the four species the blue crabs are the major delicacy and consumed by the local people, whereas the other three species are seldom consumed. However, they form part of the food chain in this coastal region (Burger and Gochfeld, 2021) and can influence the transmission of heavy metals from the soil to humans that consume other aquatic products of the river (Lambiase et al. 2021). This study is aimed at comparing the total hydrocarbon content (THC) and heavy metal concentrations of four dominant crab species. The objective of this study is, therefore, (i) to determine and compare the THC and heavy metal concentration between the four crab species; (ii) to determine and compare the THC and heavy metal concentration between the crab body parts and (iii) to compare the THC and heavy metal concentration between the internal and external body parts.

Materials and methods

Description of study area

The study area is Eagle Island and is situated directly behind the Rivers State University (Figure 1). It is a small patch of forest that was cut, and sand filled several years ago ((Numbere, 2020a)). This sand filled section is rich in biodiversity (e.g., periwinkles, crabs, fingerlings, barnacles, etc.) and over the years had shown a steady increase in its terrestrial and aquatic crustacean population. The area experiences daily tidal fluctuations, which submerges parts of the sand filled area during high tide. The salinity level shows that the river is marine or estuarine in nature. There is high amount of rainfall between February to September called the wet season, and low rainfall between October to January called the dry season. The area is also exposed to high sunshine which facilitates rapid growth and development of four mangrove species namely red, white, black, and grey. The sandy area is covered by over 10 different species of weeds (Numbere, 2020b). Other organisms found in this location include different birds (heron, king fisher), and alligators. The sandy and swampy areas are dotted by thousands of burrows constructed by the fiddler crab (*Goniopsis pelii*).



Figure 1. Map of study area showing the sampling points at Eagle Island, Rivers State, Nigeria

There are four major crab species found within this mangrove ecosystem and the adjoining river namely: fiddler crabs (*Uca tangeri*), marsh crabs (*Sesarma elegans*), swimming crab (*Callinectes amnicola*), and West African red mangrove crab (*Goniopsis pelii*) (Figure 2).



Figure 2. Some crab species captured at Eagle Island, Niger Delta, Nigeria.

Description of study species

Fiddler crabs (*Uca tangeri*): this crab is the most populated and numbered over a thousand individuals in this location. They are mostly found on the ground in their burrows on both the sandy and swampy areas of the forest. Field observations show that there are more burrows in the swampy side probably because of its closeness to the river. Their populations had also declined drastically over the years because of anthropogenic activities such as continuous sand mining, deforestation, pollution and trampling by humans that use the area for boat transportation. The males have a pronounced pincers for protecting their territory and for courtship.

Marshcrabs (*Sesarma elegans*): this crab species is the next most dominant after the fiddler crabs. They are mostly small and hide inside tiny holes created in the soil beneath the grasses that grow on the sand filled area. They mostly construct their holes at the roots level of the grasses in dry or waterlogged areas of the sand fill. Their habit of burrowing in the standing water may expose them to heavy metal accumulation, which may affect other organism that feed on them along the food chain. They are dark brown to black in color.

Swimmingcrab (*Callinectes amnicola*): this species is mainly aquatic and don't live on land but are carried onto the sand filled area during high tide. They survive temporarily inside stagnant pool of water on the sand filled area. However, their presence in the puddle predisposes them to heavy metal contamination.

West African red mangrove crab (*Goniopsis pelii*): this species is the least dominant in this location. Their population is not more than 20 at this site. They are mostly hidden from public view by hiding inside the branches of nypa palm (*Nypa fruticans*). They also bore few burrows near the palm where they hide during high tide. Their body is made of a combination of orange and black color. They also have distinct hairs on their body.

Sample collection

Ten of each species were captured alive by hand and placed in a secure container. They were taken to the laboratory and dissected into different body parts namely carapace, claw, gut, limbs, pincers, and ventral body. The body parts were then placed in labelled polytene bags and sent to the laboratory for further physico-chemical analysis of heavy metals. Their internal and external organs were placed in aluminum foil and oven dried at 70°C for 48 hours to get rid of moisture. Metal concentration from the body parts were determined by the procedures of (Dhaneesh et al. 2012).

Laboratory Analysis

Procedure of total hydrocarbon content analysis

It involved the use of spectrophotometric method using the HACH DR 890 calorimeter (wavelength 420 nm). The samples were first crushed and 2g was weighed into a glass beaker and 20 ml of hexane was added, and with the aid of a glass rod, the mixture was homogenized by stirring. Afterwards, the sample was filtered in a glass funnel packed with cotton wool, silica gel and anhydrous sodium sulphate. After this, 10 ml of the filtered organic extract was transferred into a 10 ml sample curvet and inserted into the calorimeter. The detection limit for THC is 0.01 mg/l.

Heavy metal analysis

Heavy metal extraction was done by weighing 0.25g aliquots of crab samples into a Teflon inset of a microwave digestion vessel and 2 ml concentrated (90%) nitric acid (Sigma-Aldrich, Dorset, UK) were added (e.g., Aigberua and Tarawou). The metals were extracted using a microwave accelerated reaction system (MARS Xpress, CEM Corporation, Matthews, North Carolina) at 1500 W power (100%), ramped to 175 °C in 5.5 min, held for 4.5 min, and allowed to cool down for 1 h. The cool digest solution was filtered through the Whatman 42 filter paper and made up to 100 ml in a volumetric flask by adding de-ionized water. All chemicals and reagents used were of analytical grade and of highest purity possible. Analytical blanks were prepared with each batch of the digestion set and analyzed (one blank for every set of 6 samples) in the same way as the samples. The detection limit for the three metals analyzed in mg/l i.e., Zinc, Cadmium and Lead is 0.001, 0.001 and 0.002 respectively.

Statistical analysis

An analysis of variance (ANOVA) was conducted to determine whether there was a significant difference in THC and heavy metal concentration in the different body parts of the crabs. The data was first log transformed to ensure that they were normal, and the variances were equal (Logan, 2010). Bar graphs were then used to illustrate the significance and difference in concentration in body parts and between male and female crabs. All analyses were done in R Development Core Team (2013).

Results

THC and heavy metal concentration in four crab species

The ANOVA result reveals that there is a significant difference in metal concentration in each crab species ($F_{3, 92} = 24.89$, $P=0.001$, Table 1, Figure 3). Furthermore, the interaction effect (metal vs. species) was also significant ($F_{3, 80} = 2.90$, $P=0.01$). Swimming crabs have the highest lead concentration (44.61 ± 7.34 mg/kg) while fiddler crabs have the highest THC (6.24 ± 6.11 mg/kg), cadmium (4.42 ± 1.36 mg/kg) and zinc (46.87 ± 9.07 mg/kg) concentrations. The range of cadmium in the crabs is between 3.06 ± 0.77 to 4.42 ± 1.36 mg/kg (Table 1) which is far above the international limit of 0.5 mg/kg (EU, 2006). Similarly, the range of lead (8.70 ± 5.68 – 44.61 ± 7.34 mg/kg) is above the EU limit (EU, 2006). The order of heavy metal concentration in each crab species is as follows: *C. amnicola* (Pb > Zn > Cd > THC); *U. tangeri* (Zn > Pb > THC > Cd); *S. elegans* (Zn > Pb > Cd > THC) and *G. pelii* (Zn > Pb > Cd > THC).

Table 1. Mean levels of total hydrocarbon content (THC) and heavy metals $\pm$ 1 SE in different crab species at Eagle Island, Niger Delta Nigeria

Crab species	Metals (mg/kg)			
	THC	Cd	Pb	Zn
Swimming crab (<i>C amnicola</i>)	2.20 ± 0.31	3.62 ± 0.23	44.61 ± 7.34	22.27 ± 9.74
Fiddler crab (<i>U tangeri</i>)	6.24 ± 3.11	4.42 ± 1.36	17.79 ± 6.32	46.87 ± 9.07
Marsh crab (<i>S elegans</i>)	0.82 ± 0.52	3.62 ± 0.95	19.50 ± 7.51	41.34 ± 8.52
West African mangrove crab (<i>G pelii</i>)	0.18 ± 0.11	3.06 ± 0.77	8.70 ± 5.68	36.51 ± 10.67
EU standard	2.0*	0.5*	0.5*	50*

* (EU, 2006)

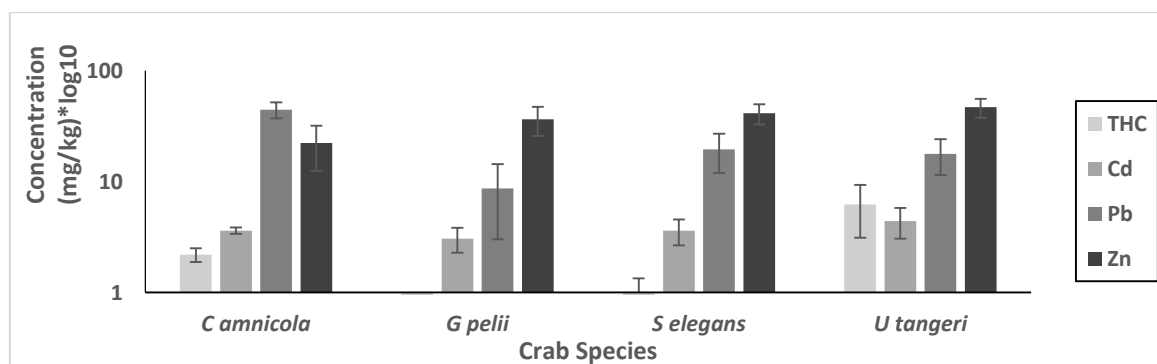


Figure 3. concentration of metals in four mangrove crab species at Eagle Island, Nigeria.

THC and heavy metal concentrations in body parts of crab species

The ANOVA result show that there is significant difference of THC and heavy metals between crab body parts ($F_{3, 72} = 26.59$, $P=0.0001$, Table 2, Figure 4). In contrast, the interaction effect (metal vs. parts) is not significant ($F_{15, 72} = 1.27$, $P=0.25$). Crab claw has the highest THC (10.35 ± 8.84 mg/kg) and lead (34.45 ± 13.11 mg/kg) concentrations. Carapace has the highest cadmium concentration (6.84 ± 1.39 mg/kg). Lastly, pincer has the highest zinc concentration (56.89 ± 6.25 mg/kg). However, the mean result of Cadmium concentration in internal organs of all crab species (i.e., gut) in this study (4.26 ± 0.72 mg/kg) (Table 2) was higher than the mean Cadmium concentration of hepatopancreas of shore crab (*Carcinus maenas*) i.e., 1.2 ± 1.1 mg/kg as revealed by Knutsen et al. (2018).

Table 2. Mean levels of total hydrocarbon content (THC) and heavy metals ± 1 SE in different parts of crabs at Eagle Island, Niger Delta Nigeria

Crab Parts	Metals (mg/kg)			
	THC	Cd	Pb	Zn
Carapace	0.65 ± 0.57	6.84 ± 1.39	18.20 ± 5.95	11.02 ± 3.42
Claw	10.35 ± 8.84	2.27 ± 0.41	34.35 ± 13.11	36.60 ± 14.55
Gut	0.54 ± 0.48	4.26 ± 0.72	13.82 ± 12.77	24.32 ± 12.28
Limbs	1.44 ± 0.81	2.20 ± 0.65	22.40 ± 11.90	41.06 ± 6.64
Pincers	0.66 ± 0.42	3.30 ± 0.81	16.55 ± 3.93	56.89 ± 6.25
Ventral	0.52 ± 0.47	3.22 ± 0.56	30.48 ± 13.13	50.58 ± 11.87

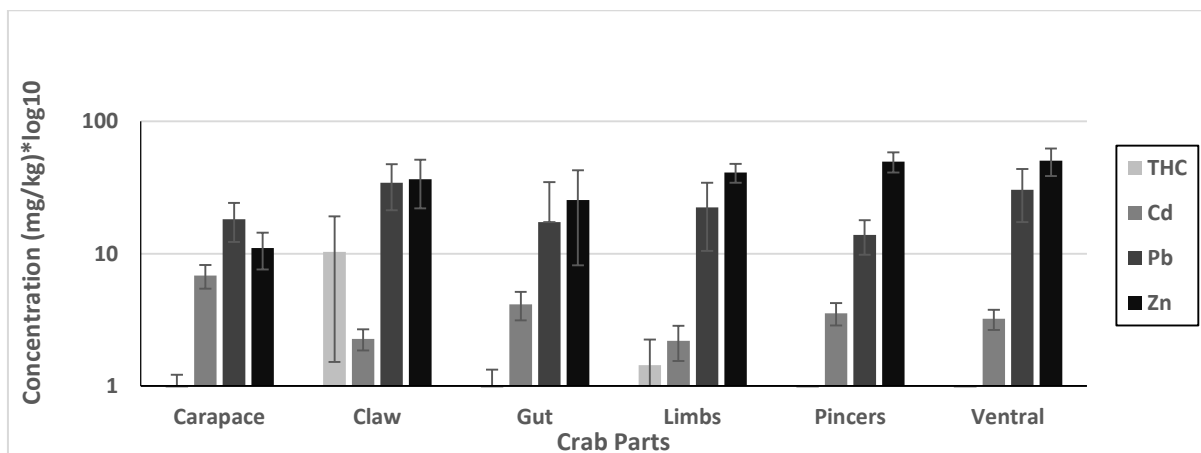


Figure 4. concentration of metals in body parts of some crab species at Eagle Island, Nigeria.

THC and heavy metal concentration between the internal and external body parts.

The ANOVA result show that there is no significant difference in heavy metals between internal and external areas of crab ($F_{1, 94} = 0.21$, $P=0.65$, Table 3, Figure 5). Similarly, the interaction effect shows that there is no significant difference ($F_{3, 88} = 0.37$, $P=0.78$). However, internal areas have higher cadmium (4.36 ± 0.46 mg/kg) and zinc (37.51 ± 11.48 mg/kg) concentrations while external areas have higher THC (2.92 ± 2.01 mg/kg) and lead (24.89 ± 4.87 mg/kg) concentrations.

Table 3. Mean levels of total hydrocarbon content (THC) and heavy metals ± 1 SE between internal and external parts at Eagle Island, Niger Delta Nigeria

Area	Metal (mg/kg)			
	THC	Cadmium	Lead	Zinc
Internal	0.68 ± 0.39	4.36 ± 0.46	15.92 ± 8.41	37.51 ± 11.48
External	2.92 ± 2.01	3.45 ± 0.56	24.89 ± 4.87	36.49 ± 5.41

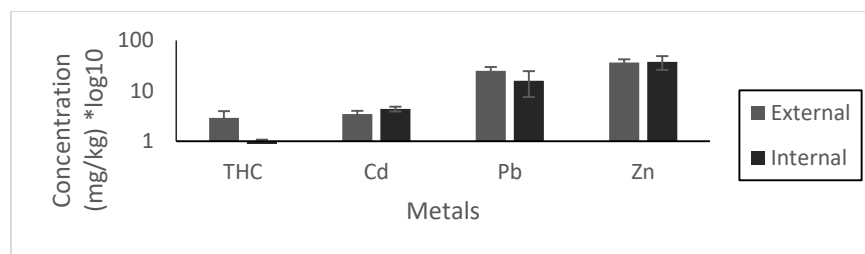


Figure 5. Concentration of THC and heavy metals in external and internal parts of four crab species at Eagle Island, Nigeria.

Discussion

The significance of heavy metals across species show that all crab species are equally endangered by heavy metal and total hydrocarbon pollution in this ecosystem. Previous research has shown that heavy metals such as cadmium and lead have toxic effects on crustaceans (Liu et al. 2019; Weis, 2012), which in turn have toxic effect on humans (Cheng et al. 2021). Their habit of crabs feeding on waste (Pinheiro et al. 2021) and burrowing into polluted soils in aquatic environment predispose them to absorption of toxic metals. Metal enrichment is caused by numerous anthropogenic activities that occur in this environment such as waste disposal, marine transportation activities (Purba et al. 2021), proliferation, and accumulation of micro and macro plastic waste brought in by tidal currents (Zhang et al. 2021), sand mining activities that release spent engine oil into the environment (Xu et al. 2021). Components of the spent oil include lead, iron, and cadmium, so it is thus not surprising that THC and other heavy metals in this study site have high concentrations in all the crab species sampled, which are above the European Union Standard for consumption (EU, 2006). However, the swimming crabs seem to have the highest concentration of lead, which is dangerous to humans because they are the species mainly consumed by local people. The high concentration of lead in the swimming crabs might be caused by their aquatic life, which expose them to constant oil spills from artisanal refinery and nearby oil companies leading to increased hydrocarbons (Lambiase et al. 2021; Marinho et al. 2021). Out of the four crab species fiddler crabs has the highest accumulation of heavy metals (i.e., THC, Cadmium and Zinc), which might be as result of their amphibious life and dexterity in burrowing in the sandy and swampy soils of the forest that had been contaminated by external additions of pollutants from decomposing plastic waste (Zhou et al. 2021), oil spill from swamp buggies used for sand mining and tidal action. Weathering process from rocks underneath the soil release chemicals that contaminate the fiddler crabs, which mostly inhabit ground burrows. Nevertheless, fiddler crabs are not mainly used as food but consumed by only few persons.

Crab claws have highest THC because they serve as the walking legs for movement, and sometimes digging of burrows. They have more contact with the soil than other parts of the body. They use it to dig and walk on polluted soils, which create high body-soil contact. Similarly, the pincers have high Zinc concentration because of increased body-soil and body-food contact. The pincers are not only used for digging but for a predatory life, which brings them in contact with their environment.

This study revealed that the carapace, being the largest surface area of the crab stores more cadmium concentration. In contrast other studies have shown that the hepatopancreas of crab is the largest store of cadmium (Wiech et al. 2017). Crabs generally are exposed daily to pollutants in their burrows and external environment due to their burrowing and feeding habit. This is possible because of the polluted state of the environment caused by adverse human activities such as dumping of plastic waste, oil spills from outboard engines that operate in the neighboring river, release of used oil by swamp buggies and sand dredgers in the locality. During feeding the crabs consume particles of sand with their food leading to contamination. Increase in metals in the body of the crabs is significant because it moves and magnify up the food chain especially when they are consumed by other higher organisms such as humans (Ali and Khan, 2019; Wang et al. 2021). Although, out of the four crabs the swimming crab (*Callinectes amnicola*) is the one mostly eaten and sold to the public. The rest are considered not edible but are still important in the transmission of metals along the following pathways: from mangrove to organism, soil to organism, and organisms to organism in the mangrove ecosystem. This is because when crabs die their remains are eaten by fish and other organisms (Looi et al. 2019), which are in turn eaten by humans (e.g., periwinkle, oysters, water crabs etc.). The internal and external parts of the crab are equally subjected to total hydrocarbon and heavy metals since they are found in a polluted environment. The study reveals that the crab population at the study site is exposed to high number of pollutants, which are above acceptable limits. Therefore, their use as a source of food should be avoided to prevent human-food contamination.

Conclusion

Crabs play significant role in the environment such as their ability to facilitate bioturbation, and decomposition of plant part, which increases soil nutrients. They also help in the re-distribution of seeds, which determines the structure and function of mangrove ecosystems. Crabs help in soil aeration which increases the oxygen content of the soil and overall productivity. However, their use as food should be done with caution to prevent contamination by harmful metals that come from negative human activities in this locality. Most coastal areas in the Niger Delta are highly polluted because of a spike in oiling activities, sabotage of oil pipelines and the proliferation of artisanal refineries. There are also unregulated marine activities (boat transportation, barge operations, refuse disposal) which results to the release of toxic fuel into the aquatic environment.

Recommendations

Since crabs are soil dwellers they can be used as bio monitors of soil pollutants. This requires constant chemical analysis of soil and crab parts to determine the concentration of THC and heavy metals. This study area can be strictly protected from adverse human activities to prevent the contamination of organisms that live in this ecosystem. Both edible and non-edible crab species are significant in metal transfer to humans, they should therefore be monitored and inspected before being sold to consumers.

References

- Aigberua, A., Tarawou, T. (2018) Speciation and Mobility of Selected Heavy Metals in Sediments of the Nun River System, Bayelsa State, Nigeria, *Environ. Toxicol. Stud. J.* 2 (2018) 1.
- Ali, H., & Khan, E. (2019). Trophic transfer, bioaccumulation, and biomagnification of non-essential hazardous heavy metals and metalloids in food chains/webs—Concepts and implications for wildlife and human health. *Human and Ecological Risk Assessment: An International Journal*, 25(6), 1353-1376
- Burger, J., & Gochfeld, M. (2021). Biomonitoring selenium, mercury, and selenium: mercury molar ratios in selected species in Northeastern US estuaries: risk to biota and humans. *Environmental Science and Pollution Research*, 28(15), 18392-18406.
- Cheng, C. H., Ma, H. L., Deng, Y. Q., Feng, J., Jie, Y. K., & Guo, Z. X. (2021). Oxidative stress, cell cycle arrest, DNA damage and apoptosis in the mud crab (*Scylla paramamosain*) induced by cadmium exposure. *Chemosphere*, 263, 128277.
- Dhaneesh, K.V. et al., Bio-accumulation of metals on reef-associated organisms of Lakshadweep Archipelago, *Food Chemistry*. 131 (2012) 985-991.
- European Commission. (2006). Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. *Off J Eur Union*, 364(365–324)
- Ghaem-Maghami, A., & Naderloo, R. (2021). Mating behavior of the Iranian fiddler crab *Austruca iranica* Pretzmann, 1971 (Decapoda: Brachyura: Ocypodidae), with an emphasis on the mate choice of burrow-mating females. *The Journal of Crustacean Biology*, 41(1), 97-107.
- Karam, Q., & Al-Wazzan, Z. (2021). Toxicity of petroleum hydrocarbons to Brachyuran crabs: a review of deleterious effects of oil-related xenobiotics on life stages. *Journal of the Marine Biological Association of the United Kingdom*, 1-16.
- Knutsen, H., Wiech, M., Duinker, A., & Maage, A. (2018). Cadmium in the shore crab *Carcinus maenas* along the Norwegian coast: geographical and seasonal variation and correlation to physiological parameters. *Environmental monitoring and assessment*, 190(4), 1-13
- Lambiase, S., Ariano, A., Serpe, F. P., Scivicco, M., Velotto, S., Esposito, M., & Severino, L. (2021). Polycyclic aromatic hydrocarbons (PAHs), arsenic, chromium and lead in warty crab (*Eriphia verrucosa*): occurrence and risk assessment. *Environmental Science and Pollution Research*, 1-11
- Li, J., Hua, G., Liu, S., Liu, X., Huang, Y., & Shi, Y. (2021). Effects of crab disturbance on nitrogen migration and transformation in a coastal tidal flat wetland. *Environmental Science and Pollution Research*, 1-12.
- Liu, J., Cao, L., & Dou, S. (2019). Trophic transfer, biomagnification and risk assessments of four common heavy metals in the food web of Laizhou Bay, the Bohai Sea. *Science of the total environment*, 670, 508-522.
- Logan, M. (2010) Biostatistical design and analysis using R: a practical guide, John Wiley and Sons, England.
- Looi, L. J., Aris, A. Z., Mohd Isa, N., Yusoff, F. M., & Haris, H. (2020). Elemental Composition and Health Risk Assessment of Giant Mudskipper (*Periophthalmodon schlosseri*) from the Intertidal Zone of the West Coast of Peninsular Malaysia. *Frontiers in Marine Science*, 7, 1107.
- Marinho, C., Nicolodi, J. L., & Neto, J. A. (2021). Environmental vulnerability to oil spills in Itapua State Park, Rio Grande do Sul, Brazil: An approach using two-dimensional numerical simulation. *Environmental Pollution*, 288, 117872

- Numbere, A. O. (2020a). Impact of Human Disturbance on Fiddler Crab (*Ucatangeri*) Burrow Morphology, Distribution and Chemistry at Eagle Island, Niger Delta, Nigeria. *Open Journal of Marine Science*, 10(4), 191-202.
- Numbere, A. O. (2020b). Diversity and Chemical Composition of Weeds in Sand-Filled Mangrove Forest at Eagle Island, Niger Delta, Nigeria. *American Journal of Plant Sciences*, 11(07), 994
- Pinheiro, M. A. A., Kriegler, N., de Souza, C. A., & de Almeida Duarte, L. F. (2021). Feeding Habit and Lifestyle Influence the Baseline Micronuclei Frequency of Crab Species in Pristine Mangroves. *Wetlands*, 41(2), 1-14.
- Purba, N. P., Faizal, I., Cordova, M. R., Abimanyu, A., Afandi, N. K., Indriawan, D., & Khan, A. (2021). Marine Debris Pathway Across Indonesian Boundary Seas. *Journal of Ecological Engineering*, 22(3).
- R Development Core Team (2013). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna Austria. <http://www.R-project.org>.
- Rocca, C., Daleo, P., Nuñez, J., Silliman, B. R., Iribarne, O., Angelini, C., & Alberti, J. (2021). Flood-stimulated herbivory drives range retraction of a plant ecosystem. *Journal of Ecology*.
- Xu, F., Jia, Y., Wang, Y., Zhang, F., Li, L., Li, Y., ...& Zhang, T. (2021). Does sand mining affect the remobilization of copper and zinc in sediments?—A case study of the Jialing River (China). *Environmental Research*, 200, 111416.
- Taylor, L. M. (2015). *Photox induced toxicity in early lifestage fiddler crab (Ucalongisignalis) following exposure to deepwater horizon spill oil*. University of North Texas.
- Tina, F. W., & Muramatsu, D. (2021). Small males of the fiddler crab *Austruca perplexa* court more in the off-peak breeding period when large males court less. *Journal of Ethology*, 1-12.
- Vu, H. D., Wiecki, K., & Pennings, S. C. (2017). Ecosystem engineers drive creek formation in salt marshes. *Ecology*, 98(1), 162-174.
- Wang, T., Hu, M., Xu, G., Shi, H., Leung, J. Y., & Wang, Y. (2021). Microplastic accumulation via trophic transfer: can a predatory crab counter the adverse effects of microplastics by body defence?. *Science of The Total Environment*, 754, 142099.
- Weis, J. S. (2012). *Walking Sideways: The Remarkable World of Crabs*, Ithaca, NY. USA: Cornell University Press.
- Wiech, M., Vik, E., Duinker, A., Frantzen, S., Bakkes, S., & Magge, A. (2017). Effects of cooking and freezing practices on the distribution of cadmium in different tissues of the brown crab (*Cancer pagurus*). *Food Control*, 75, 14–20.
- Yáñez-Rivera, B., García-Gasca, A., Corona-Vadillo, D., Aguilar-Zárate, G., Martínez-Rodríguez, I., Hernández-Cornejo, R., ...& Betancourt-Lozano, M. (2019). Multiple biomarker approach in the fiddler crab to assess anthropogenic pollution in tropical coastal environments. *Biomarkers*, 24(2), 141-152.
- Zhang, T., Sun, Y., Song, K., Du, W., Huang, W., Gu, Z., & Feng, Z. (2021). Microplastics in different tissues of wild crabs at three important fishing grounds in China. *Chemosphere*, 271, 129479.
- Zhou, A., Zhang, Y., Xie, S., Chen, Y., Li, X., Wang, J., & Zou, J. (2021). Microplastics and their potential effects on the aquaculture systems: a critical review. *Reviews in Aquaculture*, 13(1), 719-733

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Richness and Heterogeneity of In-Stream Fish Assemblage of the Lower Cross River Estuary at Oron, Southeast Nigeria

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Abstract

Updated fisheries statistics in estuaries and rivers are necessary for the formulation of sound fisheries management policy. To establish the fish composition and diversity of the Cross River Estuary at Oron, monthly fish samples were investigated for 12 consecutive months in three locations along the Cross River Estuary at Oron. A total of 2108 fishes belonging to 17 species, 14 families were identified in this study for both wet and dry seasons. The five most abundant fish families were the Claroteidae>Cynoglossidae>Sciaenidae>Cichlidae>Clupeidae. Species percentage composition by number indicated *Chrysichthys nigrodigitatus* (17.60%) >*Cynoglossus senegalensis* (13.57%) >*Pseudolithophilus senegalensis* (12.95%) >*Tilapia niloticus* (10.58%) >*Ethmalosa fimbriata* (9.77%) >*Lutjanus dendacanthus* (8.92%) >*Trichiurus lepturus* (8.40%) >*Liza falcipinnis* (7.73%). Other species recorded are <5.0 %. Smaller-sized fishes of juvenile class ranges made up the in-stream fish assemblage along Cross River estuary at Oron.

Keywords: Conservation, Exploitation, Fish association, Spatiotemporal variations

Introduction

Globally, small scale fisheries contribute to food sufficiency of nations; and livelihoods of millions of fishers and fishing communities. Yet vital information is lacking in this important fishery compared to the industrial ones. Small scale fisheries employ different fishing gears, fishing strategies and meters (i.e., the combination of a particular fishing gear, fishing area, season, target species and operational process (Stergiouet *al.*, 2006)). Cross River estuary, Oron is a major estuary of significance in Akwalbom State, southeast Nigeria. It was noted for high fish production and other lucrative marine activities. The estuary however, receives a lot of domestic wastes and sewage from the dense population of people clustering around it, as well as a large dose of runoff from the large timber market situated on its course. The objective of this study was to investigate the fish species composition (abundance, richness and diversity status) of the Oron segment of Cross River Estuary, Nigeria. The study was limited to species samples captured by artisanal fishermen whose gears are generally simple and hand operated (hooks, gillnets, traps, baskets, drums, etc.) and using simple traditional crafts (dug-out wooden canoes, bamboo rafts and small open fibre-glass boats within the stream network at Oron.

Materials and Methods

Study Area

The study was conducted at the Oron axis of the Cross River estuary (Fig.1) along three transects: upstream at Uya Oro Bridge (04° 48'13.2" N and 008° 11' 47.6" E), downstream at Museum (04°49' 37.9" N and 008° 13' 52.9" E) and at EsinUfot (04° 49' 08.5" N and 008° 14' 47.3" E) close to the river mouth where it empties into a larger channel (Fig. 1). The area has a tropical rainy climate with abundant rainfall and temperature range of 22 °C in the wet season (April to December) to 35°C in the dry season of January to March (NIMET, 2014; 2015). Station 1 features predominantly log transportation business, heavy human and vehicular traffic; Station 2 – museum, motor park, restaurant business and fishing and at Station 3 there are no industrial activities; mainly fishers. In all these sites the human population discharge untreated human and domestic wastes directly into the surrounding water channels.

Fish sample collection and identification

Only fishers exploring in-stream fishery were sampled. Fish caught outside the Oron axis but landed within the sampling sites were excluded. Fishers employed hook and lines, castnet, gillnet and traps, drums, etc., on paddled wooden/dug-out canoes (5 to 10 m LOA), or powered by small outboard engines and manned by an average of two

men. Species of fish caught were identified using field guides of FAO (1990), Idodo-Umeh (2003) and Olaosebikan and Raji (2013); measured to the nearest 0.1cm total length (TL) and 0.1g total weight (TW) and preserved in 10% normalized formaldehyde. Fish species data were converted to relative abundance values (by number and weight).

Statistical Analysis

The pooled data of catches by all gear types in each sampling Station was used in assessing abundance by calculating the index of preponderance (IP) $IP = [(\%N\%W).100] / [\sum(\%N\%W)]^{-1}$. Fishes with IP values less than (<) 0.50 were regarded as being of relatively insignificant contribution while those with IP values greater than (>) 0.50 were regarded as being of significant contribution.

Ecological biotic indices of Shannon-Weiner Diversity, $(H' = -\sum P_i \log_e P_i)$; Simpson Dominance, $D = 1 - \sum (\frac{n_i}{N})^2$, Simpson Diversity, $1-D$; Evenness, e^H/S , and Equitability, $J = H' / \log_e S$, indices and Margalef index, $(d = S - 1 / \log_e N)$ were used to describe the structure of the community and compare the sampling stations; S = total species number, n_i = Number of individuals per samples, P_i = proportion of each species in each sample (n_i/N), and N = Total number of individuals of all species (Odum, 1971). The relative diversity, RD (Mandal & Naskar, 2008; Ekpo and Udoh, 2013) calculated as: $RD = 100 \times [(Fn + Gn + Sn) \cdot N^{-1}]$, where Fn , Gn and Sn are respectively numbers of families, genera and species, and $N = 108$ (sum of numbers of families, genera and species in all the three habitats investigated in study area. of dietaries. A cluster analysis was performed on species-abundance data pairs to identify the association and natural grouping of species into four clusters (Ter Braak, 1986). All diversity indices were calculated with the aid of MS Excel and PAST[®] software (Hammer, 2011).



Fig. 1: Sampling locations at Oron along the lower Cross River, southeast Nigeria

Results

Ecological indices and ichthyofaunal composition

Table 1 provides a broad overview of the ecological indices and ichthyofaunal composition of the Oron River system. It reveals a polydiverse ecosystem (>0.5) from which a total of 2,108 fish specimens were sampled during the study period. The in-stream ecosystem accommodated a fish assemblage of about 17 fish species, 16 genera, 15 families and 6 orders. Cluster analysis (Table 2) reveal strong affinity among the in-stream fish communities delineating four clusters composed of one fish species (cluster 4) to nine fish species (cluster 1). Seasonal variations in species abundance were observed in Cichlidae, Clupeidae and Cyprinidae species (cluster 3). Bagridae, Cynoglossidae, Sciaenidae (cluster 2), Cichlidae, Lutjanidae (cluster 3) and Trichiuridae (cluster 4) exhibited significant spatial variations ($p < 0.05$): Stn 3 showing significant variations in species abundance in comparison with Stn 2 and Stn 1 ($p > 0.05$).

Table 1. Community indices in relation to sampling stations and seasons along Oron River

Number of Taxa and Diversity Indices	Sampling Stations			Sampling season	
	Uya Oro (S ₁)	Esuk Museum (S ₂)	Esuk Ata Nsulyak (S ₃)	Dry (Jan-Mar)	Wet (Apr-Dec)
No. of Family (<i>Fn</i>)	8	12	14	10	14
No. of Genera (<i>Gn</i>)	8	12	14	10	17
No. of species (<i>Sn</i>)	8	15	17	10	17
Dominance, <i>D</i>	0.2019	0.1274	0.1095	0.1315	0.1381
Simpson, <i>1-D</i>	0.7981	0.8726	0.8905	0.8685	0.8619
Shannon-Weiner Index, <i>H'</i>	1.695	2.217	2.364	2.151	2.218
Species evenness, <i>E</i>	0.7782	0.7064	0.709	0.8593	0.6128
Margalef Index, <i>d</i>	1.221	2.128	2.30	1.745	2.163
Equitability index, <i>J</i>	0.8711	0.8645	0.8730	0.9341	0.8192
Relative Diversity, <i>RD</i> (%)	21.36	34.95	43.69	40.75	59.25
No. of fish sampled	197	809	1102	582	1526

Table 2. Comparison of multi-species ichthyofaunal composition of the floodplains of the Oron River across sampling stations (habitats), sampling season and clustering

S/N	Cluster No	Family	Species	Station effect			Season effect	
				(Kruskal-Wallis ANOVA)			(T-test)	
				<i>F</i>	<i>P</i>	Duncan's test	<i>t</i>	<i>P</i>
1	1	Carangidae	<i>Caranx hippo</i> Linnaeus, 1766	0.980	0.386		0.661	0.422
2		Cichlidae	<i>Coptodon zilli</i> Gervais, 1848	0.525	0.597		2.086	0.158
3		Citharinidae	<i>Citharinus citharus</i> Hilaire, 1809	1.320	0.281		1.308	0.261
4		Clupeidae	<i>Illisha africana</i> Bloch, 1795	0.863	0.431		1.036	0.316
5		Cyprinidae	<i>Labeo senegalensis</i> Valenciennes, 1842	1.941	0.160		0.607	0.0441
6		Monodactylidae	<i>Psettus sebae</i> Cuvier, 1829	2.584	0.091		1.993	0.167
7		Mugilidae	<i>Mugil cephalus</i> Linnaeus, 1758	0.808	0.455		0.459	0.502
8		Polynemidae	<i>Pomadasys jubelini</i> Cuvier, 1830	1.435	0.253		0.459	0.502
9		Polynemidae	<i>Polydactylus quadrifilis</i> Cuvier, 1829	1.832	0.176		0.451	0.507
10	2	Bagridae	<i>Chrysichthys nigrodigitatus</i> Lacepede, 1803	4.578	0.018*	Stn 1>Stn 3>Stn 2	1.186	0.284
11		Cynoglossidae	<i>Cynoglossus senegalensis</i> (Kaup, 1858)	5.697	0.007*	Stn 3>Stn 2; Stn 1	0.133	0.717
12		Sciaenidae	<i>Pseudolithus senegalensis</i> Valenciennes, 1833	5.322	0.010*	Stn 3>Stn 2; Stn 1	3.146	0.085
13	3	Cichlidae	<i>Tilapia niloticus</i> Linnaeus, 1758	4.367	0.021*	Stn 3>Stn 2; Stn 1	7.875	0.008*
14		Clupeidae	<i>Ethmalosa fimbriata</i> Bowdich, 1825	1.720	0.195		7.849	0.008*
15		Cyprinidae	<i>Liza falcipinnis</i> Valenciennes, 1836	1.587	0.220		1.701	0.002*
16		Lutjanidae	<i>Lutjanus endecacanthus</i> Bleeker, 1863	6.550	0.004*	Stn 3>Stn 2; Stn 1	1.908	0.176
17	4	Trichiuridae	<i>Trichiurus lepturus</i> Linnaeus, 1758	9.911	0.000*	Stn 3>Stn 2; Stn 1	0.616	0.438

*significant at $p < 0.05$

The indices of preponderance (IP) indicate the abundance and distribution of the various important fish species. Figure 2 shows the indices of preponderance in descending order: Bagridae (*Chrysichthys nigrodigitatus*) was the most important occurring fish species in all the sampling stations with an IP of 42.67; followed by *C. senegalensis* (16.95), *P. senegalensis* (14.2); the least being *L. senegalensis* (0.02) and *M. cephalus* (0.01). In terms of size of fish caught (i.e., number of individuals per kg), *C. citharus* (2) and *L. senegalensis* (2) surpassed all other species. This was followed by *C. nigrodigitatus* (6) and *P. jubelini* (7), indicating that the smaller-sized fishes of juvenile class ranges made up the in-stream fish assemblage along Cross River estuary at Oron.

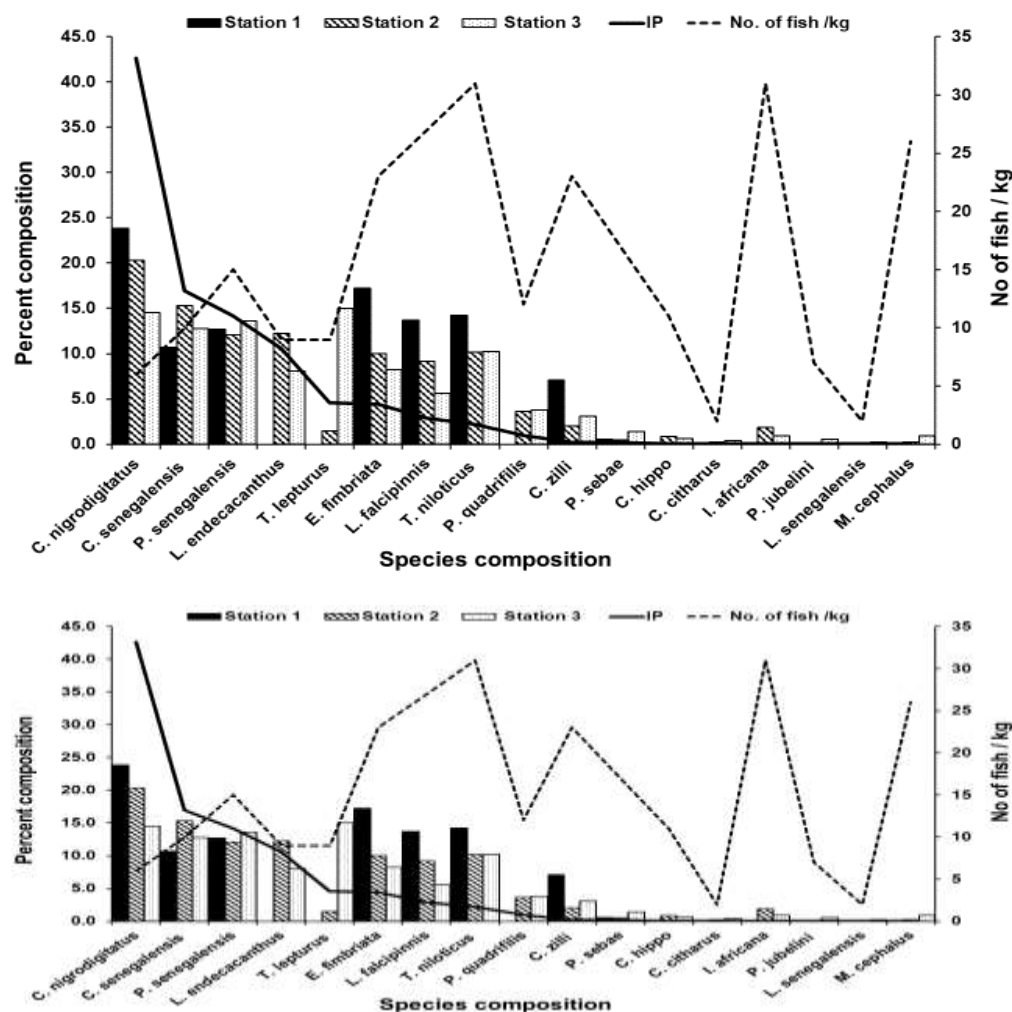


Figure 2. Fish species index of preponderance (abundance) and spatial diversity along Cross River estuary at Oron; graph also shows number of fish samples that makes a kilogramme of fish

Discussion

Species Abundance by Number Species composition

Other studies conducted in the Cross River System documented much higher species composition than result obtained in this study. Etimet *et al.*, (1994) reported on 28 different fish species; King (1996) - 165 fish species, 97 genera and 41 families; Offem *et al.* (2007) - 46 fish species, 28 genera and 16 families from the vegetational zone of the Cross River inland Wetlands, while Ekpo and Udoh (2013) reported 77 species, 52 genera and 29 families at the lower Cross River floodplain. The observed differences or seemingly low species diversity may be attributed to the limited area investigated. This study sampled fishes that were strictly caught within the Oron axis of the Cross River estuary, excluding catches from the sea and other locations which are similarly landed at the three fishing ports sampled. Other possible explanations include investigation period or number of sampling stations investigated. Such low fish diversity and quantity could also be a good indicator of a possibly stressed ecosystem (Leveque, 1995).

Fish Species Abundance

In the present study the family Claroteidae showed numerical dominance and accounts for 17.60% of total catch, followed by Cynoglossidae (13.57%), Sciaenidae (12.48%), Cichlidae (10.58%), Clupeidae (9.77%) Lutjanidae (8.92%), Trichiuridae (8.40%). This agrees with the report of Etimet *et al.* (1994) who documented *Pseudotolithus*

species, *C. nigrodigitatus*, *E. fimbriata*, *C. senegalensis* and *M. cephalus* to be the most important species at the lower Cross River Estuary.

Seasonal and Spatial Variations

The seasonal and spatial variations in the fish assemblage of Cross River System, Oron observed during the study period supports the report of Jackson and Harvey (1997) that various lake fish communities exhibit non-random patterns in composition over time and space. Higher number of fish species and individuals were caught during the wet months of the study period than in the dry months. This agrees with the work of Ikpi and Offem (2011) in South Eastern Nigeria and Harrison and Whitefield (1995), in Graham Town. The capture of the smaller-sized fishes of juvenile class ranges suggests that fishing gears with narrow selectivity were employed. Similar observations were made by Lowenberge and Kunzel (1991) from an earlier survey.

Conclusion

The fish species assemblage of the Cross River Estuary, at Oron comprised 17 species and 14 families (of 2108 fish individuals sampled). Most abundant fish were the *Chrysichthysnigrodigitatus*, followed by *Cynoglossussenegalensis*, *Pseudotolithussenegalensis* and *Tilapia niloticus*. Species composition was not as rich as reported by Etimet *et al.*, 1994 at Esuk Ata Nsulyak of lower Cross River. There is urgent need for conservation and management of the fish resources by relevant authorities through enactment and enforcement of law regulating gear type and mesh size to curb destructive exploitation.

References

- Ekpo, I. E. and Udoh, J. P. (2013). Species Richness and Diversity of Ichthyofaunal Communities of the Lower Cross River Floodplain, Nigeria. *International Research Journal of Environmental Sciences*, 2(7): 1-5.
- Etim, L., Uwe-Bassey, B. and Brey, T. (1994). Population Dynamics of the West African Croaker *Pseudotolithus elongatus* in the Cross River Estuary, Nigeria. *Scientia Marina* 5(4): 315-321.
- FAO (1990). Species Identification Sheets for Fishery Purposes. Field Guide to the Commercial Marine Resources of the Gulf of Guinea. RAFR/F1/90/2.
- Harrison, T. D. and Whitefield, A. K. (1995). Fish Community Structure in Three Temporarily Open/Closed Estuaries on the Natal Coast. *Ichthyological Bulletin of the J. L. B. Smith Institute of Ichthyology*, 64: 1-80.
- Hammer, Ø. (2011). *PAST- PAleontological Statistics* Version 2.12 Reference manual. Natural History Museum, University of Oslo, Norway, 220p. Accessed at www.nhm.uio.no in March, 2013.
- Idodo-Umeh, G. (2003). *Freshwater Fishes of Nigeria (Taxonomy, Ecological Notes, Diet and Utilization)*. Idodo-Umeh Publishers Ltd, Benin City, Edo State, Nigeria
- Ikpi, G. and Offem, B. (2011). Fish Fauna of Agbokim Waterfall in South Eastern Nigeria. *Journal of Asian Scientific Research*, 1(6): 299-311.
- Jackson, D. A. and Harvey, H.H. (1997). Quantitative and Qualitative Sampling of Lake Fish Communities. *Canadian Journal of Fisheries and Aquatic Science*, 54: 2807-2813.
- King, R. P. (1996). Biodiversity of Freshwater Fishes of the Cross River in the Rainforest Belt of Cameroun-Nigeria. In: *Essential Partnership. The Forest and the People*. A Proceedings of the Rain Forest of South-eastern Nigeria and South-western Cameroun, held at Obudu Cattle Ranch and Resort, 20-24th October, 1996, pp. 184-197.
- Leveque, C. (1995). Role and Consequence of Fish Diversity in the Functioning of African Freshwater Ecosystems: A Review. *Aquatic Living Resources*, 8:59-78.
- Lowenberge, U. and Kunzel, T. (1991). Investigations on the trawl fishery in the Cross River Estuary, Nigeria. *Journal of Applied Ichthyology* 7(1): 44-53.
- Mandal, R.N. and Naskar, K. R. (2008). Diversity and classification of Indian mangroves: a review. *Tropical Ecology*, 49(2): 131-146.
- Nigeria Meteorological Agency, NIMET (2014, 2015). Seasonal rainfall prediction (SRP) for 2014 and 2015. www.nimet-srp.com. Accessed: May 27, 2015.
- Odum, E. P. (1971). *Fundamentals of ecology* (3rd ed.). W. B. Saunders Company, Philadelphia, 574p.
- Offem, B. O., Akegbejo-Samson, Y and Omoniyi, I. T. (2007). Biological Assessment of *Oreochromis niloticus* Linne: 1958, (Pisces: cichlidae) in a Tropical Flood River. *African Journal of Biotechnology*, 6: 1966-1971.
- Olaosebikan, B. D. and Raji A (2013). *Field Guide to Nigerian Freshwater Fishes*. (Revised Edition). Remi Thomas Press, New Bussa. p. 144.

- Stergiou, K.I., Moutopoulos, Puente, E., Soriguer, M.C., Lino, P. G., Luis A Errazkin, L. A., Zabala, C., Monteiro, P., Erzini, K. (2006). Trammel net catch species composition, catch rates and metiers in southern European waters: A multivariate approach. *Fisheries Research* 79: 170–182.
- Ter Braak, C. J. F. (1986). Canonical Correspondence Analysis, a new eigenvector technique for multivariate direct gradient analysis. *Ecology*, 67: 1167–1179.

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Physicochemical and Metals Distribution in Some Selected Shell Fishes from a Fishing Port along the Opuro-Ama in Creek in Rivers State, Niger Delta, Nigeria

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Abstract

Heavy metals concentration in selected shell fishes (*Uca tangeri*, *Callinectes Amnicola*, *Tympanotonus fuscatus*, *Penaeus monodon*, Sediment and Water collected from a fishing Port along the Opuro-ama in Creek, Asari Toru Local Government area of Rivers State, Nigeria and were analysed for Manganese (Mn), Iron (Fe), Cobalt (Co) and Zinc (Zn) using Atomic Absorption Spectrophotometer. The results showed that the concentration of the metals in the tissues of all the shell fishes, the interstitial water and the sediment sampled from the creek were within the permissible limit recommended by the Department of Petroleum Resources, Environmental Protection Agency and World Health Organization. There was an overall statistical difference ($p < 0.05$) in metals concentration in the soft tissues in all the shellfish. The physicochemical parameters of the interstitial water such as pH, Temperature, Conductivity, Total Dissolved Solids (TSS) Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), and Salinity were within the acceptable levels in the guidelines for drinking water by Department of Petroleum Resources (DRP, 2002), Environmental Protection Agency (EPA, 2017) and World Health Organization (WHO, 2011). Although Chemical Oxygen Demand (COD) and the Total Suspended Solids (TSS) were slightly higher than the recommended limit of these metals by Department of Petroleum Resources (DRP, 2002). The results indicated that if the metals are not checked, they may increase the potential for bioaccumulation in the shellfishes and the creek as well. Therefore, there is need for regular monitoring of this creek to avoid future deterioration.

Keywords: Physico-chemistry, heavy metals, Shellfishes, Opuro-ama creek.

Introduction

Environmental pollution, natural or man-made is assuming enormous proportions, increasing considerably by the day, with the advent of civilization, industrialization and urbanization (Davies *et al.*, 2021). Most of the world's air, water and land are now mostly contaminated by chemical wastes from domestic, industrial processes, including those of crude oil and gas (Akankali and Davies, 2020). Consequently, the aquatic ecosystems act as one of the major receptacle ecosystem for various contaminants generated through the unregulated release of effluents from mines, smelters, industries, excessive usage of agrochemicals, and from aerial deposition (Davies and Okonkwo, 2021). In Nigeria, the input of environmental pollutants in aquatic systems is a common phenomenon. It is a common belief that aquatic systems have an unlimited capacity to absorb increasing amount and variety of waste substances and energy from our civilization (Akinrotimiet *et al.*, 2019). Aquatic environment pollution as a result of heavy metals has been a critical issue all over the world, this is because they are indestructible and most of them have toxic effects on organisms (Zhou *et al.*, 2011). Fin and shell fishes have been widely used as bio-indicators to monitor heavy metals concentrations in the coastal environment, due to their wide range of distribution, and also their important position in the food chain. Among the different kinds of pollutants, heavy metal pollution needs to be dealt with on top priority considering both its fast rate of accumulation in the aquatic medium and the impact of its toxicity on the organisms along the food chain and its biomagnification impacts (Okere *et al.*, 2021). Giving the potential environmental exposure of the Opuro-ama creek to heavy metal contamination by virtue of its position as recipient creek to many other tributaries in the Niger Delta region, it is pertinent to evaluate the likely effect of its pollution on the inhabitants and communities which depend on it for their livelihood in terms of fishery resources and other services.

Materials and Methods

Study Area

The Opuro-ama Creek is a tributary of the Bonny River which is located Southeast of the Niger Delta between longitude 6°51'E and 49.8'E, and latitude 4°43'N and 47.8'N in Asari-Toru Local Government Area of Rivers State.

The creek system consists of the main creek channel with other associated interconnecting creeks which are interconnected and surround Opro-ama and Sa-ama community. The Opro-ama Creek is known for its numerous creeks, swamps and exposed mud flats at ebb tide. The mangrove vegetation of the area comprises of species like: *Rhizophora racemosa*, *Avicennia germinans*, *Laguncularia racemosa* and *Conocarpus erectus*. Traditionally, Opro-ama creek serves as a strong livelihood support base for the people of Opro-ama community and other neighbouring villages. The creek provides ready incentive for capture fisheries, transportation, fuel wood production, domestic, sand dredging. In addition, the network of mangrove swamps within the creek basin provides the locals with ecosystem services such as shoreline protection, flood control, fish breeding grounds etc.

Collection of Samples

Shell Fish

The swimming crabs (*Callinectes amnicola*) was caught using a drag net while the Mud flat crab (*Ucatangeri*) was collected randomly from their hide out holes in the mud flat using creek using a crab trap. Periwinkle (*Tympanotonus fuscatus*) was handpicked from the mud flat too. Sampling was carried out from three different sample stations across the creek. The samples collected was persevered in an ice pack before transported to the laboratory for heavy metal concentration using atomic absorption Spectrometer.

Sediment Sample

A bottom sediments samples were collected in a composite form from three different stations using an Ekman grab sampler and kept in a plastic container which had been previously treated with 10% nitric acid for 24 hours and rinsed with de-ionized water.

Water Sample

Three pits were dogged randomly on the intertidal flat of each sample station and allow for the accumulation of the interstitial water. After fifteen minutes, the interstitial water would be collected in-situ using water collection bottle.

Determination of Heavy Metals

The Cobalt (Co), Copper (Cu), Iron (Fe), Zinc (Zn), Magnesium (Mn) were determined using the Atomic Absorption Spectrophotometer (AAS) method.

Determination of physical parameters

The interstitial water samples were collected using Schott glass bottles. The pH, interstitial water Temperature, Salinity, Conductivity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS) of the water were measured using an in-situ Handheld Multi-meter (Milwaukee Model pH600 and Laboratory Benchtop meter 860033-model). Dissolved Oxygen (DO) was measured using a Milwaukee Dissolved oxygen meter (MW 600 Model). Biochemical Oxygen Demand (BOD) was determined by the 5-day BOD test (APHA, 2005). Chemical Oxygen Demand (COD) was determined using the Closed Reflux Method 5220C with a higher concentration of potassium dichromate solution. All parameter determined were method recommended by APHA 2340C (1995) standards.

Statistical Analysis

Data will be analyzed using a one-way ANOVA and Duncan's multiple range and results will be tested for statistically significant differences at the 0.05.

Results

The physicochemical parameters of the interstitial water samples collected from the Opro-ama creek during the study period are shown in Tables 1. The pH mean concentration ranges from 6.40–6.80 with a mean value of 6.57 ± 0.06 . The overall water temperature observed at the period of study ranged from 29.70–30(°C) with a mean value of 30.0 ± 0.057 (°C) while the conductivity was between 19.6–22.7 (µS/cm) with a mean value of 21.62 ± 0.06 (µS/cm) and TDS concentration ranged from 16.0–17.43(µS/cm) with a mean value 16.61 ± 0.10 (µS/cm). The Total Dissolved Solids (TSS) concentration ranged from 94.0–140.7(µS/cm) with a mean value of 111 ± 0.58 Solids (µS/cm) while the mean values of BOD observed was between 0.53–0.87 (Mgl⁻¹) mean value of 0.68 ± 0.033 (Mgl⁻¹). The low DO values were between 3.0–3.2(Mgl⁻¹) with a mean value of 3.2 ± 0.058 (Mgl⁻¹) and the Salinity values observed was between 11.50 –11.70 (ppt) with a mean value of 11.69 ± 0.09 (ppt) during the study. The Chemical Oxygen Demand (COD) values range from 52.0–73(µS/cm) with a mean value of 64.6 ± 0.88 (µS/cm).

Table 1: Physicochemical Quality of the Interstitial Water Samples.

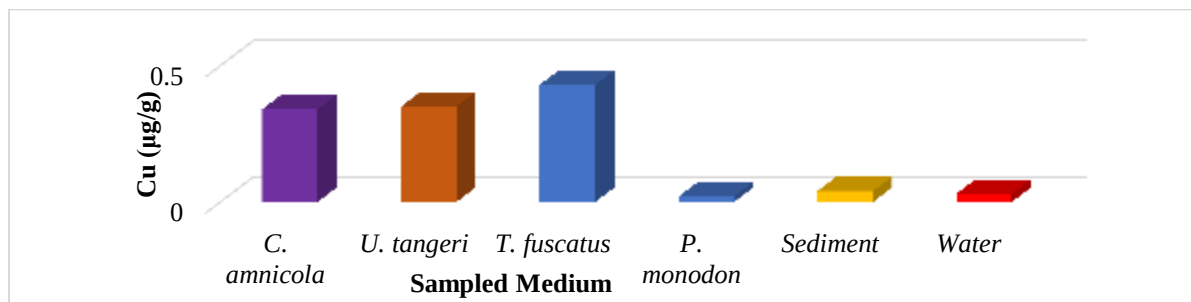
Parameters	Min-Max	Mean -SE	WHO (2011)	DPR (2002)	EPA (2017)
Temperature (°C)	29.70 - 30	30.0±0.057	24.8-30	22.32-25	27 - 30
pH	6.40 - 6.80	6.57±0.06	6.5-8.5	6.5-8.5	6.5 - 8.5
DO (Mgl ⁻¹)	3.0 - 3.2	3.2±0.058	6	5	7.5
Salinity (ppt)	11.50 -11.70	11.69±0.09	120	600	-
BOD (Mgl ⁻¹)	0.53 - 0.87	0.68±0.033	10	10	5 - 7
Conductivity(μS/ cm ⁻¹)	19.6 - 22.7	21.62±0.06	400	-	200 - 1000
Total Dissolved Solids (μS/cm)	16.0 - 17.43	16.61±0.10	2000	2000	1000 - 2000
Total Suspended Solids (μS/cm)	94.0 - 140.7	111±0.58	500-1000	30	30
Chemical Oxygen Demand (μS/cm)	52.0 - 73	64.6±0.88	40	10	-

Tables 2 Shows the heavy metals concentration in some selected Shellfishes samples from Opuro-ama Creek. The level of Copper in the shellfishes was highest in *T. fuscatus* (0.43±0.02 mg/l) followed by *U. tangeri* (0.35±0.02 mg/l) and *C. amnicola* (0.34±0.01 mg/l) and the least was observed in *P. monodon* (0.02±0.02 mg/l). There was significant variation $p < 0.05$ across the different medium. Although, no significant difference $p > 0.05$ was observed between *U. tangeri* and *C. amnicola*; and between surface water (0.03±0.02 mg/l and Sediment (0.04±0.02 mg/l). *U. tangeri* (0.45±0.02 mg/l) recorded the highest level of Zinc concentration while *P. monodon* (0.02±0.02 mg/l) recorded the least. There was significant difference $p < 0.05$ between *P. monodon* and the other shellfishes, although no significant difference $p > 0.05$ was observed between *U. tangeri*, *T. fuscatus* and *C. amnicola*. The highest values of Cobalt were recorded in *C. amnicola* (0.06±0.02 mg/l), *T. fuscatus* (0.06±0.01 mg/l) and sediment (0.06±0.01 mg/l) respectively while the least value was recorded in the water (0.01±0.01 mg/l). *P. monodon*, Water and *U. tangeri* were significant difference $p < 0.05$ from *C. amnicola*, *T. fuscatus* and sediment. The concentration of Iron in the shellfishes was highest in sediment (3.70±0.02 mg/l) followed by *U. tangeri* (3.5±0.02 mg/l) and the least was recorded in water (2.57±0.02 mg/l) and there was significant difference $p < 0.05$ across the different medium. The highest concentration of Manganese was recorded in *U. tangeri* (0.03±0.02 mg/l) while the least were recorded in *C. amnicola*, *T. fuscatus*, *P. monodon*, sediment and water (0.02±0.01 mg/l). There was no significant difference $p > 0.05$ was observed across the different media.

Table 2: Heavy Metals Composition in Some Selected Shell Fishes from a fishing Port along the Opuro-ama in Creek

Heavy Metals (μg/g)	<i>C. amnicola</i>	<i>U. tangeri</i>	<i>T. fuscatus</i>	<i>P. monodon</i>	Sediment	Water	WHO (2011)	EPA (2017)
Cu	0.34±0.01 ^b	0.35±0.02 ^b	0.43±0.02 ^a	0.02±0.02 ^c	0.04±0.02 ^c	0.03±0.02 ^c	2.0	3.0
Zn	0.43±0.02 ^a	0.45±0.02 ^a	0.40±0.02 ^a	0.04±0.02 ^c	0.12±0.02 ^b	0.01±0.02 ^c	30	30
Co	0.06±0.02 ^a	0.05±0.02 ^b	0.06±0.02 ^a	0.05±0.02 ^b	0.06±0.02 ^a	0.01±0.01 ^c	-	-
Fe	2.77±0.02 ^{cd}	3.20±0.02 ^b	2.80±0.02 ^c	3.10±0.02 ^b	3.70±0.02 ^a	2.57±0.02 ^d	0.1	0.5
Mn	0.02±0.01 ^a	0.02±0.02 ^a	0.02±0.01 ^a	0.02±0.01 ^a	0.02±0.01 ^b	0.02±0.01 ^a	0.05	0.02

* In each column, mean with a common letter are not significantly different ($P > 0.05$).

**Fig 1: Comparative values of Cu in Some Selected Shell Fishes from a fishing Port along the Opuro-ama in Creek**

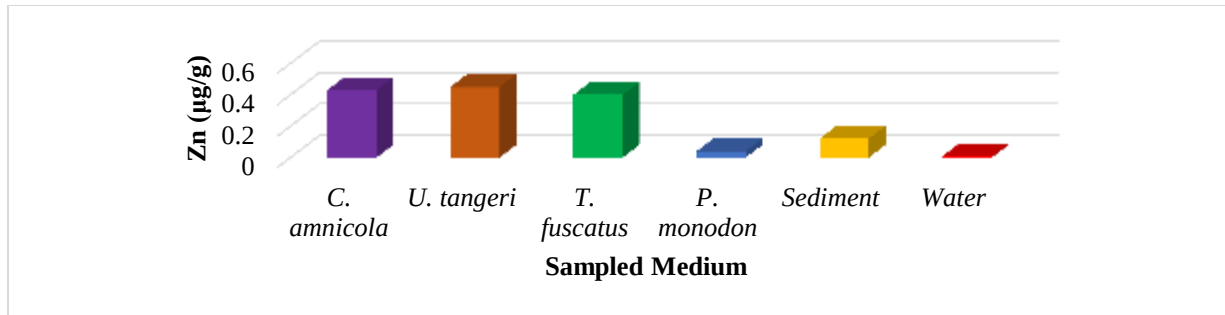


Fig 2:Comparative values of Zn in Some Selected Shell Fishes froma fishing port along the Oपुरo-ama in Creek

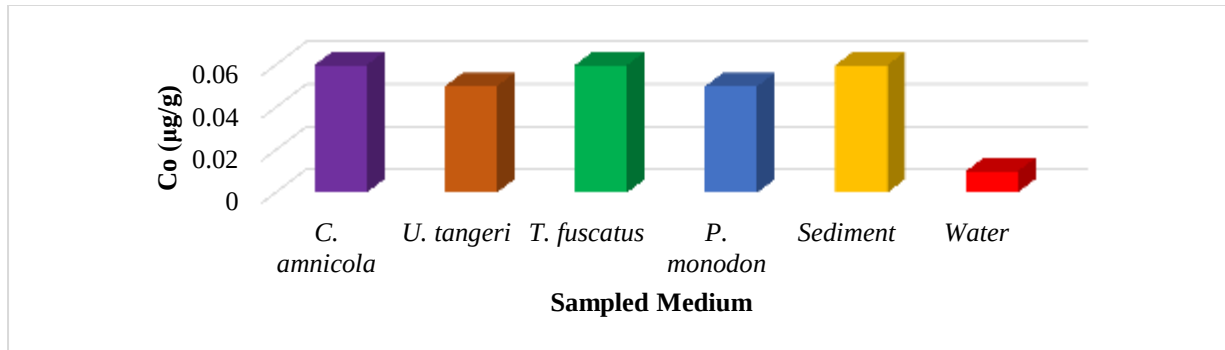


Fig 3:Comparative values of Co in Some Selected Shell Fishes froma fishing Port along the Oपुरo-ama in Creek

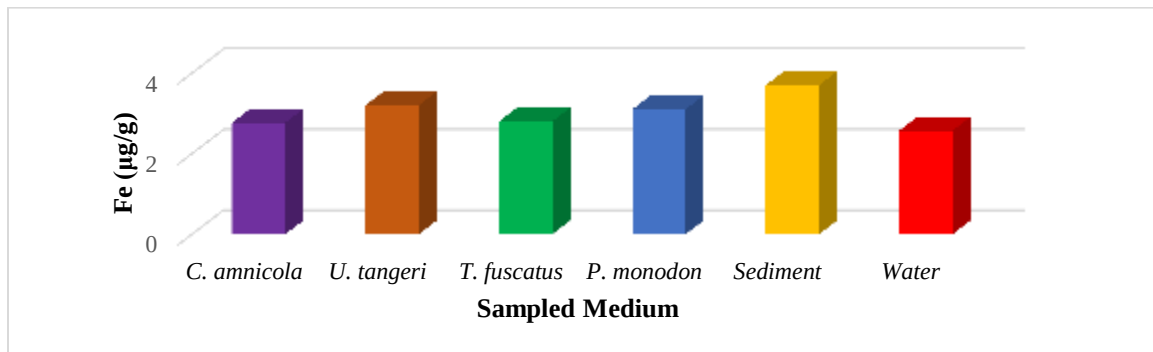


Fig 4:Comparative values of Fe in Some Selected Shell Fishes froma fishing Port along the Oपुरo-ama in Creek

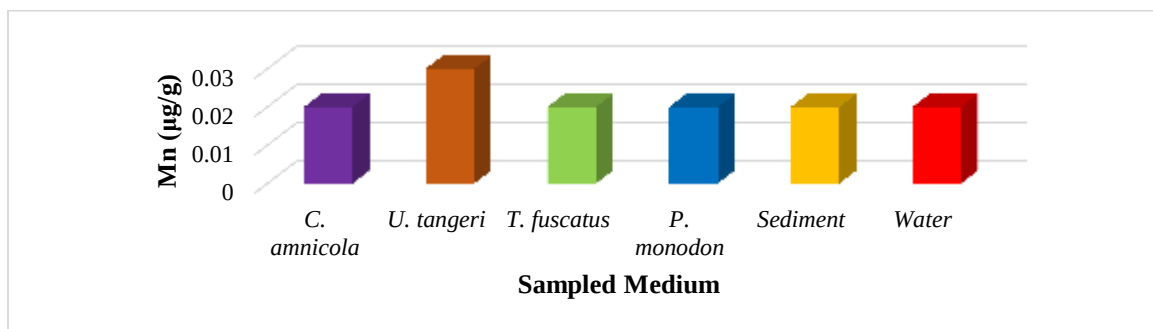


Fig 5: Comparative values of Mn in Some Selected Shell Fishes froma fishing port along the Oपुरo-ama in Creek

DISCUSSION

Physicochemical Parameter of the Interstitial Water.

The mean temperature value measured was within the range of 27-30°C recommended EPA (2017). This was also within the acceptable range by WHO (2011) and DRP (2002). This was also similar to results reported by Tosinet *al.* (2016) and Lawson (2011) in Lagos Lagoon, Lagos, Nigeria. The overall mean pH measured was 6.57 within the range of 6.5 – 8.5 as being ideal for supporting aquatic life by WHO (2011); DPR (2002) and EPA, (2017). Efeet *al.*, (2011) reported similar results from Ogunpa River at Bodija, Ibadan. The reported in the study, which is within the acceptable limit for freshwater bodies, was similar to those reported by Davies *et al.* (2021) along the Tin Can Island in Lagos, Nigeria. The mean DO measure in station one (3.2 mg/l) was below the recommended level of 6-7.5mg/L for the culture of freshwater organisms. This could be due to the high organic contents from anthropogenic activities peculiar to the study area. Similar value was reported by Zabbey (2012) in the interstitial water quality of soft-bottom flats at Bodo creek. the mean DO value was within the recommended levels (Lawson, 2011). The BOD was also within the recommended values of ideal to supporting aquatic life by WHO (2011) and EPA (2017). This result did not agree with the assertion by Atobatele *et al.* (2005) who reported that the higher the concentration of BOD, the lower the concentration of DO. Total Dissolved Solids ($\mu\text{S}/\text{cm}$), Conductivity ($\mu\text{S}/\text{cm}^{-1}$) and Salinity (ppt) were also within the permissible limit of WHO (2011); DPR (2002) and EPA (2017). Similar observations were reported in the adjoining creeks and lagoons in Lagos and its environments by Nwankwo and Onyema (2007) and Onyema and Popoola (2013). Although Chemical Oxygen Demand (COD) and the Total Suspended Solids (TSS) were slightly higher than the recommended limit by World Health Organisation (WHO, 2011) and Department of Petroleum Resources WHO (2011); (DRP, 2002). The high COD values were indication of the presence of organic and inorganic pollutants, respectively. This could be attributed to the domestic sewage from various activities of human residing around the studied area, reception of effluents containing (Okere *et al.*, 2020). Similar result was reported by Eswari and Ramanibai (2004) in southeast coast of India.

Heavy Metals Composition

From the study, the heavy metals recorded varied from species to species. The species *T. fuscatus* and *T. coronata* were found to have higher values of Cu while the least was recorded in the interstitial water. This could be attributed to the fact that these shellfishes are bottom dwellers and can easily bio-accumulate (Davies *et al.*, 2021). This assertion agrees with the findings of Minet *al.* (2011). who compared heavy metals in *Anadara granosa* and *periwinkle* in Malaysia. Similar result was reported by Akinrotimi *et al.* (2019) attributed higher heavy metals in periwinkle to its shape and life history of some commercially important shell in Port-Harcourt. Mean values of Zinc recorded in this study were highest in *U. tangeri* and least in the interstitial water. The values from all the shell fish species including the sediment and water were within the acceptable limits of WHO (2011) and EPA (2017). The values from this study was lower when compared to the values obtained in some shell fishes from lagoon systems in the Southern Gulf of Mexico which were higher than the values of Zinc obtained in some shell fishes considered by Mohammad *et al.* (2011). The high concentration on cobalt which was observed *C. amnicola*, *T. fuscatus* and the sediment could be attributed to the water chemistry, duration of exposure to contaminants to the sediment leading to the increase in the concentrations of contaminants in their habitat, feeding habits or season of sampling (Ross, 2014). high concentration on cobalt which was observed in *C. amnicola*, *T. fuscatus* could be related to their specific and feeding habits and the bioconcentration capacity of each species (Tuzen, 2003). Iron levels observed in these shell fishes, sediment and water obtained in this work were all above acceptable limits for human consumption of 0.5-1.0 mg/kg as reported by (FAO, 2002). The result was not in accordance with Vitamin (2001), who stated that the median iron concentration in rivers was reported to be 0.7 mg/litre. He also stated that in anaerobic groundwater where iron is in the form of iron (II), concentrations will usually be 0.5–10 mg/litre. Concentrations of iron in drinking-water are normally between 0.1-0.5mg/litre WHO (2011) and EPA (2017). Although higher in countries where various iron salts are used as coagulating agents in water-treatment plants and where cast iron, steel, and galvanized iron pipes are used for water distribution (Baltimore, 1979). The accumulations of metals were generally found to be different shell fish species were higher than the value recorded in the sediment and the interstitial water except for manganese was not significantly different across board. The concentration on manganese which was observed *C. amnicola*, *T. fuscatus*, *T. fuscatus*, *P. monodon*, sediment and the water were within the acceptable limits of WHO (2011) and EPA (2017).

Conclusion and Recommendation

The results showed that the concentration of the metals in the tissues of all the shell fishes, the interstitial water and the sediment sampled from the creek were within the permissible limit recommended by the Department of Petroleum Resources (DRP, 2002), Environmental Protection Agency (EPA, 2017) and World Health Organization (WHO, 2011). There was an overall statistical difference ($p < 0.05$) in metals concentration in the soft tissues in all the shellfish. The physicochemical parameters of the interstitial water such as pH, Temperature, Conductivity, Total Dissolved Solids (TSS) Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), and Salinity were within the acceptable levels in the guidelines for drinking water by Department of Petroleum Resources (DRP, 2002), Environmental Protection Agency (EPA, 2017) and World Health Organization (WHO, 2011).

There is need for regular monitoring of the metallic level in this creek to avoid future deteriorations should therefore be periodically checked to avoid increase in the potential for bioaccumulation of these metals in the shellfishes and the creek water as well.

References

- Akankali, J.A. and **Davies, I.C.** (2020). Analysis of heavy metals concentration in different media of Iwofe Creek, Niger Delta, Nigeria; *International Journal of Scientific and Research Publications*, 10(04): 2250-3153.
- Akinrotimi, O. A., Amachree, D., & Gentle, C. G. (2019). Metal concentrations in some commercially important shell in Port Harcourt, Rivers State, Nigeria. *International Journal of Fisheries and Aquatic Studies*. 7(2): 134-138
- Atobatele, O. E., Morenikeji, O. A., & Ugwumba, O. A. (2005). Spatial variation in physical and chemical parameters of benthic macroinvertebrate fauna of River Ogunpa, Ibadan. *The Zoologist*, 3, 58-67.
- Davies, I. C., Agarin, O. J., and Onoja C. R. (2021). Study On Heavy Metals Levels and Some Physicochemical Parameters of a Polluted Creek Along the Tin Can Island in Lagos. *International Journal of Environment and Pollution Research*. 9(2), 25-39.
- Davies, I. C. and Okonkwo, S. E. (2021). Analyses of Some Heavy Metal and Nutrients of Water Samples from Ajegunle Creek in Lagos. *International Journal of Environment and Pollution Research*. Vol.9, No.1 pp.7-26.
- Emere, M. C., & Nasiru, C. E. (2009). Macroinvertebrates as indicators of the water quality of an urbanized stream, Kaduna Nigeria. *Nature and Science*, 7(1), 1-7
- Efe, O., Kokoette, E. I., & Alex, U. A. A. (2012). Physico-chemical parameters and benthic macroinvertebrates of Ogunpa river at Bodija, Ibadan, Oyo State. *European Journal of Scientific Research*, 85(1), 89-97.
- Eswari, Y. N. K., & Ramanibai, R. (2004). Estuarine copepod abundance and diversity in relation to environmental variables, southeast coast of India. *Journal of the Marine Biological Association of India*, 46(1), 10-20.
- Min, K. S., Kee, K. P., & Tien, S. K. (2011). Proximate Analysis and Heavy Metal Concentrations of Tissues of Cockles (*Anadara granosa*) from Several Cockle Farms in Peninsular Malaysia; Analisis Proximat dan Logam Berat dalam Tisu Kerang (*Anadara granosa*) di Beberapa Tapak Akuakultur di Semenanjung Malaysia. *Sains Malaysiana*, 40(2):139-146.
- Mohammad M, Sary AA, Khodadadi M. Determination of heavy metals in two barbs, *Barbus grypus* and *Barbus xanthopterus* in Karoon and Dez Rivers, Khoozestan, Iran. *Bull Environment Contain Toxicology*. 2011; 87:158-162
- National Research Council. (1994). *Alternatives for ground water cleanup*. National Academies Press.
- Okere, M.C., Davies, I.C. and Okonkwo, S.E. (2020). Seasonal Variation of the Hydro-Environmental Factors and Phytoplankton Community around Waters in Tincan Island, Lagos State, Nigeria. *Journal of Applied Sciences & Environmental management*. 24(10) 1739-1746
- Okonkwo, S. E.; Davies I. C; Okere M.C. (2021): Assessment of Physico-Chemical Characteristics and Phytoplankton of a Polluted Tidal Creek In Ajegunle, Lagos. *British Journal of Environmental Sciences* 9(1): 51-69
- Okere, M. C., Davies, I. C., Onyena, A. P. (2021). Variation of The Physico-Chemical Parameters, Nutrients and Some Selected Heavy Metals Around the Waters of the Tincan Island in Lagos, Nigeria. *British Journal of Environmental Sciences*, 9(4), 1-17.
- Okonkwo, S. E.; Davies I. C; Okere M.C. (2021): Assessment of Physico-Chemical Characteristics and Phytoplankton of a Polluted Tidal Creek in Ajegunle, Lagos. *British Journal of Environmental Sciences* 9(1): 51-69.
- Onyema, I. C., & Popoola, R. T. (2013). The physico-chemical characteristics, chlorophyll a level and phytoplankton dynamics of the east mole area of the Lagos Harbour, Lagos. *Journal of Asian Scientific Research*, 3(10), 995-1010.

- Onyema, I. C., Okpara, C. U., Ogbabor, C. I., Otudeko, O., & Nwankwo, D. I. (2007). Comparative studies of the water chemistry characteristics and temporal plankton variations at two polluted sites along the Lagos lagoon, Nigeria. *Ecology Environment and Conservation*, 13(1), 1.
- Parvathi, K., & Sivakumar, P. (2016). A study on the combined effect of probiotics on the water quality of freshwater fishpond. *International Journal of Current Science Research*, 2(4), 524-529.
- Ross S. M. (2014). Toxic Metals in soil – plant systems. Wiley, Chichester. UK. 653pp.
- Tuzen M. (2003). Determination of heavy metal in fish samples of middle black sea (Turkey) by graphite furnace atomic absorption spectrometry. *Food Chemistry*. 80:119-173.
- Tosin Okomoda, V., Oloyede Tihamiyu, L., & Iortim, M. (2016). The effect of water renewal on growth of *Clarias gariepinus* fingerlings. *Croatian Journal of Fisheries: Ribarstvo*, 74(1), 25-29.
- Lawson, E. O. (2011). Physico-chemical parameters and heavy metal contents of water from the Mangrove Swamps of Lagos Lagoon, Lagos, Nigeria. *Advances in biological research*, 5(1), 8-21.
- Woke, G. N., Umesi, N., & Oguzor, N. S. (2016). Effect of size on proximate composition and heavy metal content of the mangrove oyster *Crassostrea gasar* from the Andoni River, Nigeria. *Global Journal of Agricultural Research*, 4(5), 17-27.
- Vitamin, H. (2001). Mineral Requirements. *Report of a joint FAO/WHO expert consultation Bangkok, Thailand*, 181-94.
- Zabbey, N. (2012). Spatial and temporal variability in interstitial water quality of soft-bottom flats at Bodo creek, eastern lower Niger Delta, Nigeria. *Tropical Freshwater Biology*, 21(1), 83.
- Zhou, Y. W., Peng, Y. S., Li, X. L., & Chen, G. Z. (2011). Accumulation and partitioning of heavy metals in mangrove rhizosphere sediments. *Environmental Earth Sciences*, 64(3), 799-807.

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The Length weight relationship of selected fish species of Ivo River, Ebonyi State, Nigeria**Ekpenyong, J. J., Okey, I. B., Akinrotimi, O. A., Ogueji, E. O., Iheanacho, S. C and E. B. Tabi**¹Department of Fisheries and Aquaculture, Alex Ekwueme Federal University, Ndufu-Alike, Ebonyi State²Department of Fisheries and Aquatic Science, University of Cross River, Obubra campus, Cross River State³African Regional Aquaculture Center, Port Harcourt, Rivers State*Corresponding Author: joekpenyong@gmail.com, 08120998949**Abstract**

The length-weight relationship (LWR) of selected fish species of Ivo River was determined. The fish species studied were *Parachanna obscura*, *Alestes nurse*, *Tilapia zilli*, *Arius gigas*, *Hepsetos odoe*, *Clarias gariepinus*, *Heterobranchus longifilis* and *Malapterurus electricus*. A total of 132 samples belonging to seven families were captured from the river by a local hired professional fisherman using gill nets, hooks of different sizes and wooden traps, and after which the samples were preserved in 10% formalin solution. Total length (cm) and weight (g) were measured to estimate the growth pattern of selected fish samples in the river. *T. zilli* showed isometric growth pattern. *P. obscura*, *A. nurse*, *A. gigas*, *C. gariepinus* and *M. electricus* indicated negative allometric growth while *H. odoe* and *H. Longifilis* were positively allometric. The LWR of each species was estimated using regression equation. The estimated b values of the LWRs for all species ranged from 2.886 to 3.522.. There was a high coefficient of determination ranging from 0.921 to 0.999 which indicated a strong positive relationship between the length and weight of species used for the study.

Key words: length-weight, fish species, relationship, Ivo River**Introduction**

Fish serves as a very good and cheap source of animal protein which contains essential nutrients required by the body for growth (Abowei *et al.*, 2009). It also provides a source of livelihood for fishermen who ply their trade in the fishing communities which becomes necessary to ensure that the relative wellbeing of the fish in the aquatic ecosystems are maintained for a maximum yield. This study was carried out to assess the length-weight relationship of selected fish species of Ivo River. Ivo River flows through Abiacho down to Ihie community along Afikpo road (all in Ebonyi State) where it meets with Aku River which is responsible for the change from Ivo's clear clean nature to the present brown colour. Being the largest river in the area, it plays dominant role in meeting the domestic and economic needs of the villagers.

The relationship between length and weight of fish expressed in the equation ($W = aL^b$) is a very important management tool in fishery science (Ndiaye *et al.*, 2015). It provides information useful in the conservation and monitoring of fisheries resources (Pan *et al.*, 2018) and in understanding the growth patterns and general wellbeing of different fish species in any aquatic ecosystem. The b value gives information on how the fish is growing. When $b = 3$, it means the fish is growing isometrically (which means that both the weight and length are growing at the same rate). Values of b greater than and less than 3 indicates that the fish has a positive and negative allometric growth, respectively. Despite the fact that the fisheries resources of Ivo River serve as the main source of animal protein for the rural community who depend on it for their livelihood, there is a dearth of information on their LWR. This study will therefore give the baseline information on the condition and growth pattern of fish species in the study area.

Materials and Methods

The experimental fishing was carried out in Ivo River. Ivo River is one of the fresh water habitats located within Ishiagu district in Ivo Local Government Area of Ebonyi State. The river lies within latitude 5°43' and 5°51' North and 7°29' and 7°35' East. Fish sampling was done by the assistance of local hired professional fishermen using gill nets, line and hooks of different sizes and wooden traps. A total of 128 fish belonging to seven families were sampled and identified using morphological features as described by Olaosebikun and Raji (2013) and Idodo-Umeh (2003). The total lengths of the fish samples were taken and recorded to the nearest centimetre using measuring board while the weights were determined using KERRO electronic digital weighing balance to the nearest 0.1gram. The relationship between the length and weight of the fish was established using the equation $W = aL^b$ (Ricker,

19...), where W = weight of the fish (g), L = length of the fish (cm), a = proportionality constant (intercept) and b = regression coefficient (slope). The degree of the relationship was calculated by the determination coefficient (r^2).

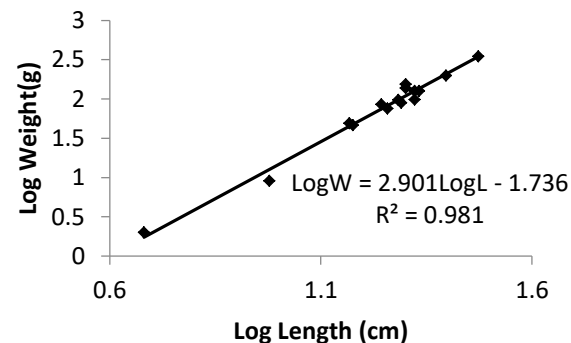
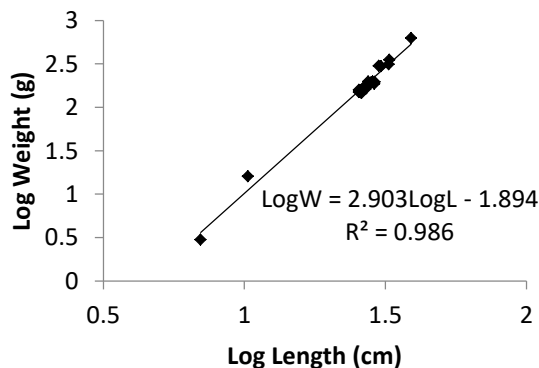
Results

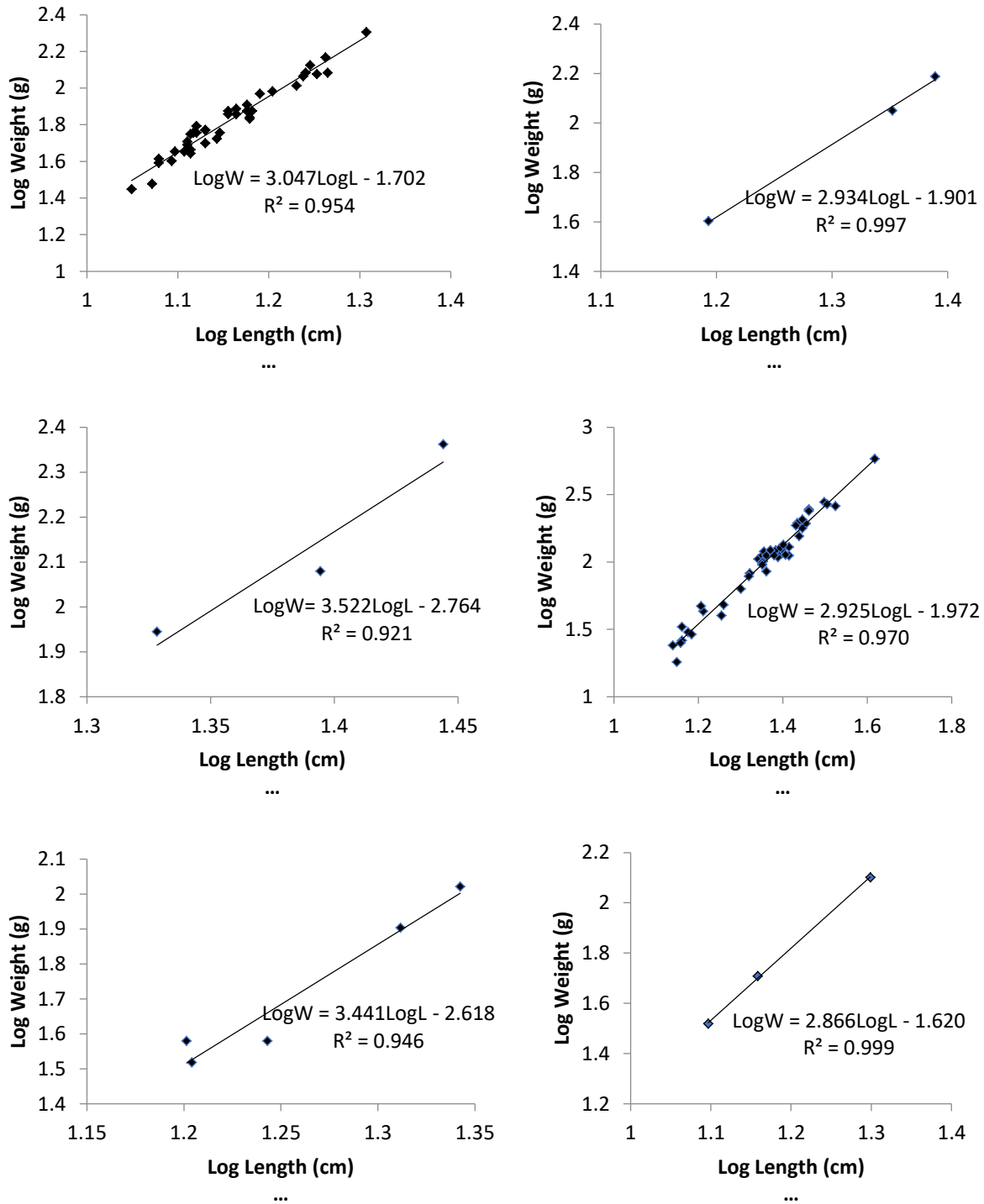
The Length-weight relationships of eight fish species viz *P. obscura*, *A. nurse*, *T. zilli*, *A. gigas*, *H. odoe*, *C. gariepinus*, *H. longifilis* and *M. electricus* belonging to seven families viz Channidae, Alestidae, Cichlidae, Ariidae, Hepsetidae, Clariidae, Malapteruridae were determined as presented in table 1. The graphical presentation of the LWRs for all species is also shown in Fig. 1-8

Table 1: Length-weight relationship parameters of eight fish species from Ivo River

S/N	Family/Fish species	N	Length range (min-max) (cm)	Weight range (min-max) (g)	a	b	r^2	Growth type
1	Channidae							
	<i>Parachanna obscura</i>	19	7.0-32.7	3-627	-1.894	2.903	0.986	- A
2	Alestidae							
	<i>Alestes nurse</i>	15	4.8-29.7	2-347	-1.736	2.901	0.981	- A
3	Cichlidae							
	<i>Tilapia zilli</i>	39	11.2-20.3	30-202	-1.702	3.047	0.954	I
4	Ariidae							
	<i>Arius gigas</i>	3	15.6-24.5	40-154	-1.901	2.934	0.997	- A
5	Hepsetidae							
	<i>Hepsetus odoe</i>	3	21.3-27.8	88-230	-2.764	3.522	0.921	+ A
6	Clariidae							
	<i>Clarias gariepinus</i>	45	13.8-41.5	18-582	-1.972	2.925	0.970	- A
	<i>Heterobranchus longifilis</i>	5	15.9-22	33-105	-2.618	3.441	0.946	+ A
7	Malapteruridae							
	<i>Malapterurus electricus</i>	3	12.5-19.9	33-126	-1.620	2.886	0.999	- A

N: total number of samples, **a:** proportionality constant (intercept), **b:** regression coefficient (slope), **r^2 :** coefficient of determination, **- A:** negative allometric growth, **I:** isometric growth, **+ A:** positive allometric growth





The highest number of samples was recorded for *Clarias gariepinus* (45) followed by *Tilapia zilli* (39), *Parachanna obscura* (19), *Alestes nurse* (15), and *Heterobranchius longifilis* (5) while *Arius gigas*, *Hepsetus odoe*, and *Malapterurus electricus* each recorded 3 samples being the least number. The observed maximum total length among all individuals sampled during the study was 41.5 cm which was recorded for *C. gariepinus* while the least total length (4.8 cm) was obtained in *A. nurse*. The smallest (2 g) and the biggest (627 g) individual sampled were found in *A. nurse* and *P. obscura* respectively. The estimated *b* values ($b < 3$) of the LWRs for *P. obscura*, *A. nurse*, *A. gigas*, *C. gariepinus* and *M. electricus* was 2.903, 2.901, 2.934, 2.925 and 2.886 respectively which indicated a negative allometric growth pattern for those species. *T. zilli* (3.047) showed isometric growth pattern for all samples.

The estimated b value for *H. odoe* (3.522) and *H. longifilis* (3.441) was greater than three indicating a positive allometric growth. There was a high coefficient of determination ranging from 0.921 for *H. odoe* to 0.999 for *M. electricus* which indicated a strong positive relationship between the length and weight of species used for the study.

Discussion

The result of this study revealed that the fish species of Ivo river exhibited isometric, negative and positive allometric growth pattern with regression coefficient equal to, less than and greater than 3 respectively. Length-weight relationship gives vital information on the growth pattern of fish species (Osho and Usman, 2019). The LWR for *P. obscura* ($b = 2.903$) indicated an allometric growth pattern which agrees with Olurin and Savage (2011) and Olanrewaju *et al.* (2017) who recorded a similar result for male *P. obscura* from river Oshun and Eleyele reservoir, south-west Nigeria respectively. Similar result was also reported in Anambra River, South-East Nigeria by Osho and Usman (2019) who studied the length-weight relationship, condition factor and fecundity of the african snakehead. Positive allometric growth recorded in this study for *H. odoe* ($b = 3.522$) and *H. longifilis* ($b = 3.441$) agrees with Ude *et al.* (2011) who reported similar growth type for both species from Ebonyi River, Nigeria. Laval and Bichi (2014) reported the LWR of 11 commercial fish species of Daberam Reservoir, Katsina State. The value of $b = 2.4737$ recorded for *C. gariepinus* in their study indicate a negative allometric growth similar to b value of 2.925 obtained in this study. A similar study of *C. gariepinus* by Fafioye and Oluajo (2005) in Epe Lagoon, Nigeria also had result of negative allometric growth of the fish, $b = 2.88$. However, an assessment of the *C. gariepinus* by Kembenya *et al.* (2014) in Lake Baringo, Kenya and Ude *et al.* (2011) in Ebonyi River, Nigeria found b values of 3.25 and 4.2630 respectively, indicating a positive allometric growth, a deviation from this study. A negative allometric growth ($b = 2.901$) was recorded for *A. nurse* in this study which agrees with Lawal and Bichi (2014) who reported an estimated b value of 2.3460 for same species in Daberam Reservoir, Katsina State. Both results disagree with Ahmed (2013) and Ude *et al.* (2011) who reported isometric growth ($b = 3.000$) and positive allometric growth ($b = 4.3762$) for *A. nurse* in Jebel Aulia Dam, Sudan and Ebonyi River, Nigeria, respectively. Assessment of *T. zilli* in this study showed an isometric growth pattern ($b = 3.047$) for all individuals. On the contrary, previous works by Ajagbe *et al.* (2016) and Oginni (2020) on same fish species at Asjire Lake, Oyo State and Egbe Reservoir, Ekiti State respectively, showed allometric growth type. The estimated b values of 2.934 and 2.886 recorded for *A. gigas* and *M. electricus* respectively showed a negative allometric growth and is similar to b value of 1.41 recorded for *M. electricus* (Obasohan *et al.*, 2012) but disagrees with b values of 3.09 (Oribhabor *et al.*, 2011) and 3.5302 (Ude *et al.*, 2011) recorded for *A. gigas*. The variability in length-weight relationship between single fish species may be due to the differences in populations and habitat as well as differences in environmental factors and conditions (Uneke, 2013).

Conclusion

Modelling the relationship between length and weight of a species of fish has become necessary as the synthetic analysis of length-weight relationships for a species can provide important insights into the ecology of the species. The study revealed that the weight of the species used can be predicted by taking the length measurement. This was seen in the high regression coefficient for all the species which is an indication that there was a strong relationship between length and weight of fish species used.

References

- Abowei, J. F. N., Davies, O. A. and Eli, A. A. (2009). Study of the length-weight relationship and condition factor of five fish species from Nkoro River, Niger Delta, Nigeria. *Current Research Journal of Biological Sciences*, 1(3): 94-98.
- Ahmed, F. M. Y. (2013). Length-weight relationships, relative condition factor and relative weight of Characidae fish in Jebel Aulia Dam, Sudan. *International Journal of Marine, Atmospheric and Earth Sciences*, 1(1): 1-7.
- Ajagbe, S. O., Odulate, D. O., Idowu, A. A., Ajagbe, R. O., Alao, D. O. and Adegkunle, A. O. (2016). Length-weight relationship and condition factor of Redbelly tilapia (*Tilapia zilli*) caught with gillnets in Asejire Lake, Oyo State, Nigeria. *International Journal of Fisheries and Aquatic Studies*, 4(1): 448-452.
- Fafioye, O. O. and Oluajo, O. A. (2005). Length-weight relationships of five fish species in Epe lagoon, Nigeria. *African Journal of Biotechnology*, 4(7): 749-751.
- Idodo-Umeh, G. (2003). Freshwater fishes of Nigeria. Taxonomic, Ecological notes, Diet and Utilization). Idodo-Umeh Publishers Ltd, Benin City. 232pp
- Kembenya, E. M., Ogello, E. O., Githukia, C. M., Aera, C. N., Omondi, R. and Munguti, J. M. (2014). Seasonal

- changes of length-weight relationship and condition factor of five fish species in Lake Baringo, Kenya. *International Journal of Sciences: Basic and Applied Research*, 14(2): 130-140.
- Lawal, I. and Bichi, A. H. (2014). Length-weight relationship and condition factor of 11 commercial fish species of Deberam Reservoir, Katsina State. *Entomology and Applied Science*, 1(3): 32-35
- Ndiaye, W., Diouf, K., Samba, O., Ndiaye, P. and Panfili, J. (2015). The length-weight relationship and condition factor of white grouper (*Epinephelus aneneus*, Geoffroy Saint Hilaire, 1817) at the south-west coast of Senegal, West Africa. *International Journal of Advanced Research*. 3(3): 145-153.
- Obasohan, E. E., Imasuen, J. A. and Isidahome, C. E. (2012). Preliminary studies of the length-weight relationships and condition factor of five fish species from Ibiekuma stream, Ekpoma, Edop State, Nigeria. *Journal of Agricultural Research and Development*, 2(3): 61-69.
- Oginni, O. (2020). Length-weight relationship of *Tilapia zilli* fish species collected from Egbe Reservoir, Ekiti State, Southwest Nigeria. *Science Letters*, 8(1): 43-47.
- Olanrewaju, A. N., Ajani, E. K., Kareem, O. K. K. and Orisasona, O. (2017). Length-weight relationships and state of well-being of *Parachanna obscura* Gunther 1861, in Eleyele Reservoir, southwestern Nigeria. *Fisheries and Aquaculture Journal*, 8(3): 1-8.
- Raji A. (1998). Field Guide to Nigerian Freshwater Fishes. Federal College of Freshwater Fisheries Technology, New Bussa. 106pp
- Olurin, K. B. and Savage, O. D. (2011). Reproductive biology, length-weight relationship and condition factor of the African snake head, *Parachanna obscura*, from River Oshun, South-west Nigeria. *International Journal of Fisheries and Aquaculture*, 3: 146-150.
- Oribhabor, B. J., Ogbibu, A. E., and Udo, M. T. (2011). The length-weight relationships of brackish water/marine fish species assemblage in a Niger Delta Mangrove Creek, Nigeria. *Current Research Journal of Biological Sciences*, 3(6): 616-621.
- Osho, F. E. and Usman, R. A. (2019). Length-weight relationship, condition factor and fecundity of African snakehead, *Parachanna obscura* from the Anambra River, South East Nigeria. *Croatian Journal of Fisheries*, 77: 99-105.
- Pan, L., Peng, Z., Shao, D., Yang, T., Wang, Z., Zeng, Z. and Shi, X. (2018). Length-weight relationship of four fish species from the Yellow river, China. *Journal of Applied Ichthyology*, 34: 1094-1096.
- Ude, E. F., Ugwu, L. L. C., Mgbenka, B. O. and Nwani, C. D. (2011). Evaluation of length-weight relationship of fish species of Ebonyi River, Nigeria. *Nigerian Journal of Fisheries*, 8(1): 136-144.
- Uneke, B. I. (2013). Morphometric parameters and condition factor of *Tilapia zillii* (Perciformes: Cichlidae) of the mid Cross river flood system, Southeastern Nigeria. *Continental Journal of Animal Veterinary Research* 6(1):1-10.

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Effects of *Spondiathus preussii* Leaf Powder on Selected Haematological Parameters and Condition Factor of African Catfish (*Clarias gariepinus*)

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Abstract

The study investigated the alterations in haematological parameters and condition factor (K) of African catfish (*Clarias gariepinus*) exposed to *Spondiathus preussii* leaf powder during a long term experimental period in static renewable bioassay system. The fish with mean weight and length of 300 ± 11.54 (g) and 40.00 ± 1.15 (cm) respectively were exposed to 1.00, 1.10 and 1.20g/l concentrations of *Spondiathus preussii* leaf powder for 7 - days. During the experimental period, some physicochemical parameters such as pH, temperature, total dissolved solids, dissolved oxygen, ammonia and nitrite were monitored daily. At the end of the experimental period, fish blood was collected to determine: Packed cell volume (%), Haemoglobin (g/dl), Red Blood Cells, White Blood Cell, Platelet, Mean Corpuscular Haemoglobin Concentration (gdl⁻¹), Mean Corpuscular Haemoglobin (pg), Mean Corpuscular Volume (fl), Neutrophils (%), Leucocrit (%), Eosinophils (%), Monocytes (%) and Basophils (%). Fish weight (g) and length (cm) were also measured for K (Condition Factor). Total dissolved solids, ammonia and nitrite increased significantly ($p < 0.05$) while pH and dissolved oxygen decreased ($p > 0.05$) with increase in the concentration of plant leaf powder. Temperature was within range as control. All the haematological parameters dropped except WBC, Platelets, MCH, MCV and N which were significantly ($p < 0.05$) raised with increase in plant powder concentration. K values generally dropped with increase in *Spondiathus preussii* leaf powder concentration when compared with control.

Keywords: *Spondiathus preussii*, Condition factor, bioassay, haematology.

Introduction

Piscicides are often used to control competing species in fish production, especially in small water bodies/enclosures, eradicate fish to control parasites, and conserve or restore native species but their uses are not encouraged because of their toxicity to aquatic organisms and the degradation of the environment. The introduction of most chemicals into the aquatic environment occurs both directly and indirectly and the accumulative chronic effect of the toxicants on aquatic organisms is extremely hazardous to fish. There are many indigenous sources of botanical fish toxicants in Nigeria that are extremely toxic to a wide range of animals including fish. The introduction of some of these piscicides in the aquatic ecosystem will eventually lead to physiological stress in aquatic organisms and ultimately reduce production (Warren, 1977). Many plants contain chemicals which have traditionally been used to harvest fish in almost all parts of the world (Jennes, 1967). *Spondianthus preussii* is tropical swampy trees belonging to *Euphorbaceae* and commonly found in Africa. The leaf and stem bark contain extremely hazardous, very toxic acid as well as *saponins*, *flavonoid* and *Tanins*. All part of the plants is extremely poisonous and medicinal value of the plant is still unknown (Istvan, 2000 and Keay *et al.* 1964). Fish farmers in Nigeria have persistently and indiscriminately abused these natural plant piscicides by using much higher concentrations than necessary, causing mass mortality of fish in ponds, contaminating the freshwater bodies and affecting non target organisms.

Clarias gariepinus is a freshwater fish found in the tropical regions of West Africa (Nyamweya *et al.*, 2010. This species is widely distributed in Asia and Africa and inhabit most lakes, ponds and rivers where they feed mainly on plankton, insects' larvae, snails, crustaceans, worms and small fishes (Bruton, 1979). *Clarias* species is of the family *Clariidae* and apart from tilapia, *Clarias* is the most cultured fish species in Nigeria and are generally strong fish, they possess an accessory respiratory organ, comprising a paired shaped air chamber containing two arborescent structures located on the fourth bronchial arcs, that are supported by cartilage and covered by highly vascularised tissue which can absorb oxygen directly from the atmosphere. Since the air chamber communicates directly with the pharynx and the gill- chamber, this accessory air breathing organ enables them tolerate adverse aquatic conditions where other cultured fish species cannot survive. They grow faster with additional supplementary feed; the demand for the fish is very high due to its oily flesh (Nyamweya *et al.*, 2010) .

Materials and Methods

Location: This experiment was carried out at the University of Port Harcourt Demonstration fish Farm, Choba Port Harcourt Rivers State.

Sample Collection and Preparation: The fresh samples of the piscicide (*Spondianthus preussii*) was collected from the forest between Choba and Emouha of Rivers State, Nigeria and identified in the Forestry Department, University of Port Harcourt. The sample was washed and oven- dried at 100 °C, ground into fine powder and stored in a container till it was ready for use.

Test Fish Species: The fish was obtained from Aqualife consult, a reputable farm in Rivers State. Care was taken to minimize stress on adult fish during transportation with a 50 liter plastic container.

Acclimation: This was done for a period of 7 days. During this period, the fish was fed once daily with an artificial feed at 3% body weight.

Experimental Set-up: 3 treatments with 3 replicates each besides control (3 replicates) were set up. 1.00, 1.10 and 1.20 grams of piscicide were respectively dissolved in 1 litre of water at each treatment levels and 20 litres of water was used per container at all levels of treatments. 12 fish with mean weight and length of 300g and 40cm respectively were stocked in the 12 tanks (1fish per tank), control inclusive.

Experimental Design: Complete randomised design.

Physicochemical Parameters: Temperature, dissolved oxygen (DO), Ammonia, Nitrites, pH, Total dissolved solids were determined using standard methods.

Haematological Analysis: 5mls of blood sample was collected from each replicate in the treatment group using disposable syringes and preserved in Ethylene diaminetetra acetic acid (EDTA) bottles. In determining haematological parameters the methods of Blaxhal and Daisley (1973) were used or otherwise stated.

Haemoglobin was estimated by cyanomethaemoglobin method recommended by International Committee for Standardization in Haematology (ICSH 1996 and 1997). Neubauer's hemocytometer (Baker and Silverton, 1982) was used for counting of white blood cell. Using white cell pipette the blood was drawn upto 0.5 mark and the diluting fluid to 11 mark. Thus the dilution was 1:20.

Haematocrit or Packed Cell Volume was obtained by centrifuging blood (containing 5mg/ml EDTA) in a graduated tube until corpuscles were packed down to a constant volume. The volume of packed cell was then expressed as a percentage of the original volume of blood. With the aid of capillary pipette a Wintrobe's haematocrit tube was filled to the 100 mark with the anticoagulated blood and centrifuged for 5-10 mm at 700RPM. As the original column of blood in the tube is 100mm long, the volume of packed cell is read directly as %age. The analysis was done according to England and Walford (1972).

Mean Cell Volume (MCV): The MCV is the average volume of red cells and was calculated from the haematocrit (Hct .packed cell volume) and red cell count (TRBC).

$$MCV = \frac{PCV(\%) \times 10 \text{ cubic microns}}{RBC (\text{million/m})}$$

Mean Cell Haemoglobin (MCH): The MCH is the content (Weight) of the Hb of the average red cell. It was calculated from the Hb concentration and red cell count.

$$MCH = \frac{Hb(g/dl) \times 10 \text{ micrograms}}{RBC (\text{million/m})}$$

Mean Cell Haemoglobin Concentration (MCHC): The Mean cell haemoglobin concentration in g% for 100ml erythrocytes was calculated by following formula:

$$MCHC = \frac{Hb(g/dl) \times 100ml}{PCV(\%)}$$

Differential Leucocyte Count: A thin blood film was made by spreading a blood drop evenly on clean grease free slide using smooth edged spreader. Giemsa's and Leishman's stains were employed for the staining of blood films.

Using the 40 objective high-power lens, 100 leucocytes were counted in the blood smear. The percentage of each of the five basic leucocytes (Neutrophils, Eosinophils, Basophils, Lymphocytes, Monocytes) was calculated and DLC reported in percentage.

Fulton's Condition Factor: Values of Fulton's condition factor were calculated using the formula:

$$\text{Fulton condition factor (K)} = \frac{\text{Weight of Fish}}{l^3} \times 100 \quad (\text{Fang et al., 2009}).$$

Statistical Analysis: Result was subjected to statistical analysis with Duncan's multiple range f-test to test for significant difference ($P < 0.05$ between various concentrations of the *Spondianthus preussii* and control).

Results

Marked behavioral changes like swift opercula movement, sudden jerky swimming body movements, loss of balance, respiratory distress, were literally observed on *C. gariepinus* adult as the concentration of *Spondianthus preussii* leaf powder increased. pH decreased with increase in toxicant concentration and differs significantly ($p > 0.05$) when compared with control (Table 1). Temperature, dissolved oxygen and nitrite did not differ significantly ($p > 0.05$) with increase in concentration – Table 1. Total dissolved solids (TDS) and ammonia (NH_3) differed significantly ($p < 0.05$) when compared with control - Table 1. The exposure of *C. gariepinus* to *Spondianthus preussii* leaf powder caused the mean values of PCV, HB, MCHC, RBC and L to decrease with increase in concentration of the toxicant. Their values peaked at treatment 0.00 mg/l (control) and the least at treatment 1.2 g/l. WBC, Platelets and N were raised with increase in concentration of the toxicant when compared with the control. The 3 blood parameters (White blood cells - WBC, Platelets and neutrophils - N) peaked at treatment 11.00 mg/l and least at 0.00 mg/l (control). The mean values of MCV, MCH, M and E, fluctuated while B was not found. MCV and MCH peaked at treatment 1.10g/ l and least at control. At 1.20g/l, M and E had the least values and highest at control - Table 3. The highest condition factor (K) was at 0.00g/l and lowest at 1.20g/l. K, ranged from 0.47 to 0.35 as shown in Table 2.

Table 1. Physicochemical parameters

TREATMENTS	pH	TEMP	TDS	DO	NH ₃	Nitrite
T ₀ 0.00g/l	8.5 ± 1.15 ^b	32.6 ± 1.27 ^c	15 ± 1.15 ^b	7.0 ± 0.011 ^a	0.18 ± 0.011 ^b	0.04 ± 0.011 ^a
T ₁ 1.00g/l	7.1 ± 1.27 ^c	31.4 ± 1.27 ^c	31 ± 1.15 ^b	5.0 ± 0.011 ^a	1.5 ± 0.011 ^b	0.80 ± 0.011 ^a
T ₂ 1.10g/l	7.0 ± 1.27 ^c	32.5 ± 1.27 ^c	44 ± 1.15 ^b	4.9 ± 0.011 ^a	1.3 ± 0.011 ^b	1.0 ± 0.011 ^a
T ₃ 1.20g/l	6.9 ± 0.011 ^a	31.6 ± 1.27 ^c	62 ± 12.7 ^d	4.8 ± 0.011 ^a	1.26 ± 0.06 ^a	1.2 ± 0.011 ^a

Mean ± SE with same superscript across column values are not significantly different ($p > 0.05$.)

Keys: TEMP. = Temperature (°C); TDS = Total dissolved solid; DO = Dissolved oxygen; NH₃ = Ammonia

Table 2. Condition factor (k) of *C. gariepinus*.

Conc.(mg/l)	MEAN WEIGHT	MEAN LENGTH	K
0.00g/l	300 ± 11.54 ^a	40.00 ± 1.15 ^a	0.47
1.00g/l	300 ± 11.54 ^a	41.16 ± 1.01 ^a	0.43
1.10g/l	300 ± 11.54 ^a	43.33 ± 1.20 ^b	0.37
1.20g/l	260 ± 11.54 ^a	42.16 ± 1.48 ^c	0.35

Mean ± SE with same superscript across column values are not significantly different ($p > 0.05$.)

Table 3. Haematological parameters of *C. gariepinus*

TREAT MENTS	PCV	HB	RBC	WBC	PLT	MCHC
0.00g/l	45 ±1.15 ^a	15.0 ±1.15 ^a	6.2±1.27 ^b	7.5±1.27 ^b	153±14.52 ^c	33 ±1.15 ^a
1.00g/l	40 ±1.15 ^a	13.3±1.27 ^b	5.9±1.27 ^b	9.3±1.27 ^b	180±17.3 ^e	32±1.7 ^a
1.10g/l	34 ±1.15 ^a	11.3 ±1.27 ^b	4.5±1.27 ^b	11.2±1.27 ^b	225±12.7 ^d	31 ±1.15 ^a
1.20g/l	30 ±1.15 ^a	10.0 ±1.21 ^b	4.1±1.27 ^b	12.5±1.27 ^b	262±12.7 ^d	30 ±11.5 ^c

Mean±SE with same superscript across row values are not significantly different (p>0.05.)

Table 3. Haematological parameters of *C. gariepinus*

TREAT MENTS	MCH	MCV	N	L	E	M	B
0.00g/l	24 ±1.15 ^a	73 ±1.15 ^a	25 ±1.15 ^a	63 ±1.15 ^a	5±1.15 ^a	7±1.15 ^a	-
1.00g/l	22±1.15 ^a	68±12.7 ^d	30±11.5 ^c	62±12.7 ^d	3±1.15 ^a	5±1.15 ^a	-
1.10g/l	25 ±1.15 ^a	76 ±12.7 ^d	35 ±12.7 ^d	60 ±11.5 ^c	2±1.15 ^a	3±1.15 ^a	-
1.20 g/l	24 ±12.7 ^d	73 ±12.7 ^d	38±11.2.7 ^d	55 ±12.7 ^d	2±1.15 ^a	5±1.15 ^a	-

Mean±SE with same superscript across row values are not significantly different (p>0.05.)

Key: PCV = Packed cell volume (%) HB = Haemoglobin (g/dl); RBC = Red Blood Cells; WBC = White Blood Cell; PLA = Platelet ; MCHC = Mean Corpuscular Haemoglobin Concentration (gdl) MCH = Mean Corpuscular Haemoglobin (pg); MCV = Mean Corpuscular Volume (fl); N =Neutrophils (%); L = Leucocrit (%); E = Eosinophils (%); M= monocytes (%); B = Basophils (%).

Discussion

The report by Muhammad *et al.*, (2010), Ajani and Ayoola (2010) and Ayuba and Ofojekwu (2002) which noted that fish exposed to varied concentrations of some toxic plants extracts exhibited marked behavioral changes like swift opercula movement, sudden jerky swimming body movements, loss of balance, respiratory distress, which demonstrated a sensitive indicator of physiological stress is in agreement with this work. The behavioral responses observed in this work are also in agreement with that of Nwani *et al.*, (2012) who also reported abnormal movements and high respiration rate in tilapia exposed to glyphosate herbicide. The findings on temperature, dissolved oxygen (DO), ammonia, nitrites, pH, total dissolved solids in this work were within acceptable range for fresh water fish culture as recommended by Boyd, (1979). This means that the results obtained in this study were not affected by physicochemical parameters of the culture tanks.

Stressors evoke non-specific responses in fish which enables the fish to cope with the disturbance and maintenance of its homeostatic state - Barton, (2002). If severe or long lasting, the reaction then becomes dangerous and threatens the fish health and comfort. Therefore, in the presence of stressors (contaminants/pollutants), blood parameters and blood chemistry can be employed as a standard laboratory test to determine diseased conditions and metabolic disorder in fish, Celik, 2004. In the present investigation, it has been discovered that low level sublethal contact of these compounds reduced hematological parameters. Omoregie *et al.*, (1910) reported that toxicants and pollutants have significant effects, which can result in several physiological dysfunctions in fish which induces changes in blood parameters.

Change of the blood cell distribution has been correlated with the changes in environmental conditions, De Wilde, 1967. The exposure of *C. gariepinus* adult to sublethal concentrations of *Spondiathus preussii* leaf powder caused a significant decrease in packed cell volume, haemoglobin, Red blood cell, MCHC, monocyte, leucocyte, erythrocyte and monocyte of the fish. The decrease in hemoglobin concentration is similar to those reported in *C. gariepinus* exposed to cassava effluents and tobacco (*Nicotiana tabacum*) leaf extracts (Adeyemo, 2005). This pattern of response may be attributed to hemolysis which results in hemodilution, a means of diluting the hemoconcentration of the leaf thus reducing the effect of the toxicants/pollutant in its system. This effect on *C. gariepinus* might have been achieved through failure or suppression of normal mechanisms promoting erythropoiesis and/or deficiency of some factors required for the maturation of the red cell. The causes of leucopenia observed in the present study are supposed to be according to the degeneration, depression, depletion and destruction of the blood forming materials by the active content of the leaf. The hemoglobin, hematocrit, red blood cells, MCHC, leucocytes and monocytes values depletion in the fish could be credited to the lysis of erythrocytes as reported by Kori-Siakpere and Ubogu, 2008. Thus, the significant reduction in these parameters is an indication of severe anemia. The slight fluctuations recorded in MCV and MCH of this work could be due to the reduction in cellular blood iron, resulting in reduced oxygen carrying capacity of blood and eventually stimulating erythropoiesis. Christensen *et al.*, 1978 reported that

white blood cells in fish respond to various stressors including infections and chemical irritants. Thus increasing or decreasing numbers of white blood cells are a normal reaction on the exposure of toxicants, Kori-Siakpere and Ubogu (2008). In the present investigation the increase in WBC (leukocytosis) may have resulted from the excitation of defense mechanism of the fish to counter the effect of the toxicant. The increase observed in percentage neutrophils in this work is attributed to tissue damage. Finally, a slight but significant increase of platelets was recorded in this investigation.

The morphometric index which provides information on the physiological state of fish in their different habitats in relation to its welfare is generally referred to as Condition factor (K). It is based on the principle that fish with better growth rate are in a better condition. The condition factor recorded in this work ranged between 0.35 and 0.47 which is in agreement with that of Anyanwu *et al.* (2007) who reported 0.319 - 0.869 for *C. gariepinus*.

Conclusion

In conclusion, the alteration of all the haematological parameters and condition factor in this experiment shows that the use of *Spondiathus preussii* leaf powder for fishing in our streams and rivers by fishers is deleterious and should be highly discouraged. Relevant authorities saddled with the responsibility of protecting our water bodies should take note. There is also need for further research on the impact of this plant on other aquatic organisms that is of economic importance to man.

References

- Adeyemo OK. Haematological and histopathological effects of cassava mill effluent in *Clarias gariepinus*. *African Journal of Biomedical Resources*. 2005;8: 179-83.
- Ajani, E.K. and S.O. Ayoola, (2010). Acute toxicity of piscicidal plant extracts (*Adeniacissam peloides*) on Tilapia (*Sarotherodon galilaeus*) Juveniles. *Iranica Journal of Energy and Environment* 1: 246-254.
- Ayuba V.O and Ofejekwu ,P.C (2002) Acute toxicity of root extract of Jimso's weed (*Daturain noxia*) to the African catfish (*Clariasgariepinus*) fingerlings, *Journal of Aquatic sciences* 17(2).
- Baker, S.J. and R.E. Silverton, (1982). Introduction of Medical Laboratory Technology. 5th Edn., Butterworth IScientific Publications, London.
- Barton AB (2002). Stress in fishes: a diversity of responses with particular reference to changes in circulating corticosteroids. *Integr Comp Biol*.;42:517-25
- Boyd, C.E. (1979). Water quality in warm water fish ponds. Craftmaster Auburn, Alabama, USA, Printers Inc.
- Bruton, M. N. (1979). The food and feeding behaviour of *Clarias gariepinus* (Pisces: Clariidae) in Lake Sibaya, South Africa, with emphasis on its role as a predator of cichlids. *The Transactions of the Zoological Society of London*, 35(1), 47–114.
- Celik ES. (2004). Blood chemistry (electrolytes, lipoproteins and enzymes) values of black scorpion fish (*Scorpaena porcus*) in the Dardanelles. *Turkey J Biol Sci*.4:716-9.
- Christensen GM, Faindt JT, Poeschi BA.(1978). Cells, proteins and certain physical-chemical properties of brook trout (*Salvelinus fontinalis*) blood. *J Fish Biol*. 12:51- 60.
- De Wilde MA, Houston AH.(1967). Haematological aspects of the three moacclimatory process in the rainbowtrout, *Salmo gaiirderi*. *J Fish Res Board Can.*;24: 2267- 81
- England, J.M ; Walford D.M and Wate D.A.W (1972): Re-assessment of the Reliability of the Haematocrit. *British Jorirnal of Haetnatology* 23, 247.
- Fang , J.K.H., Au, D.W.T. and Chin, A.K (2009). The use of physiological indices in rabbit fish (*Siggenos oramin*) for monitoring of coastal pollution. *Marine Pollution Bulletin*, 58,1229 – 1235.
- Istvan, U. (2000). Semi-natural products and related substances as alleged botanical pesticides. *Pest Management Science*. 56(8): 703-705.
- ICSH (1967). Recommendations for haemoglobinometry in human blood. *Journal of Haematology* Supply 13:71–75.
- Jennes J (1967). The use of plants as fish poison within the Kanji basin. In: Reed W(Ed). Fish and fisheries of Northern Nigeria. Ministry of Agriculture of Nigeria: p 226
- Keay, R.W.J; Onochie, C.F.A.; and Stanfield (1964). Nigerian trees. Federal Department of Forestry Research, Ibadan. Volume II. Pp 16-187.
- Kori-Siakpere O, Ubogu EO. (2008). Sublethal hematological effects of zinc on the freshwater fish, *Heteroclariassp.* (Osteichthyes: Clariidae). *Afr J Biotechnol.*;7(2) 68-73

- Muhammad A, Tufail S (2010). Replacement rotenone by locally grown Herbal extracts. *Int. J. Agric. Biol.* 12(1):77-80.
- Blaxhall, P.C. and Daisley, K.W. 1973. Routine haematological methods for use with fish blood. *Journal of Fish Biology*, 5(6): 771–781.
- Nwani, C.D., Lakra, W.S., Nagpure, N.S., Kumar, R., Kushwaha, B. and Srivastava, S.K.(2010). Mutagenic and genotoxic effects of Carbosulfan in fresh water air-breathing fish *Channa punctatus* (Bloch) using micronucleus assay and alkaline single-cell gel electrophoresis. *Food and Chemical Toxicology*, 48: 202–208.
- Omoriegie E, Ufodike EBC, Keke IR.(1990). Tissue chemistry of *Oreochromis niloticus* exposed to sublethal concentration of Gammaxan 20 and Actellic 25EC. *J Aquat Sci.* ;5:33-6
- Nyamweya, C. S., Mlewa, C. M., Ngugi, C. C., and Kaunda-Arara, B. (2010). Validation of daily growth of African catfish *Clarias gariepinus* (Burchell 1822) young-of-the-year from Lake Baringo, Kenya. *Lakes and Reservoirs: Science, Policy and Management for Sustainable Use*, 15(4), 341–345
- Sowemimo, O.A. (2007). Prevalence and intensity of *Toxocaracanis* (Werner, 1782) in dogs and its potential public health significance in Ile-Ife, Nigeria. *Journal of Helminthology* 81, 433–438..
- Wintrobe, M. (1974): Clinical hematology . Philadelphia, Lea and Febiger, 7th ed.
- Warren, C.E. (1977). Biology and water pollution. *W.B.Sanders and Company, Philadelphia. U.S.A.*, 434 p.

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Behavioural Responses of *Oreochromis niloticus* Juveniles Exposed to Sub-Lethal Concentrations of Cypermethrin

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Abstract

The behavioral responses of *Oreochromis niloticus* juveniles exposed to sub-lethal concentrations of cypermethrin (CYP) were evaluated. The fishes were acclimatized for 14 days and exposed to sub-lethal concentration of 0.0 µg L⁻¹, 0.5 µg L⁻¹, 1.1 µg L⁻¹ and 2.1 µg L⁻¹. Changes in fish behavior involved loss of equilibrium, abnormal mucus secretion, erratic swimming, air gulping activity, abnormal opercula ventilation and alteration of skin coloration. Four of the avoidance behavior viz loss of equilibrium, erratic swimming, air gulping, and opercular ventilation showed a biphasic trend where there was a dose and duration dependent increase in week 2 and 6 but decreased in week 8. The dose and duration dependent increase was however consistent across all treated groups in mucus secretion and colour change. Findings of the present study confirm that cypermethrin strongly affected the behaviour of fish even at sub-lethal level.

Key words: Behavior, cypermethrin, fish, freshwater, sub lethal, toxicity.

Introduction

Cypermethrin (CYP) is a commercial synthetic pyrethroid that is widely used in Nigeria by farmers. It is a systemic and contact pesticide effective against a wide range of insect pests particularly Lepidoptera in cereals, citrus, cotton, forestry, fruits, soyabeans, tobacco, tomatoes, vegetables and other crops (Charles and Hance 1968). In Africa and other parts of the world, pyrethroids have proven successful as a malaria control method, as the use of insect-treated nets has been correlated with a 27% reduction in the risk of post-neonatal deaths (Lindsay and Martens 1998). However extensive use of pyrethroids and particularly CYP has endangered aquatic life (Seth and Saxena 2004). CYP is particularly harmful in water to fish, marine invertebrates and other living species.

Drummond *et al.* (1986) stated that behavioral and morphological changes in fish can be used according to their mode of action as a diagnostic endpoint for screening and differentiating chemicals. After exposing 30 day old fathead minnows (*Pimephales promelas*) to various chemicals, they concluded that selecting abnormal responses is promising to predict the mode of action of unknown xenobiotics. The abnormal behavior exhibited by fish may be due to abnormal neurotransmitter levels. Such modifications occur much earlier than mortality (Ogueji *et al.* 2019). Pesticides are deposited in tissues such as the liver and muscle, contributing to organ failure and resulting mortality (Srivastava and Kaushik 2001). For normal biological function, various enzymes are essential and intervention in enzyme activity acts as a primary indicator of contaminant toxicity (Jensen *et al.* 1991). In the region where the research was carried out, CYP is widely used for insect control in agriculture, which could find their way into fish ponds and natural bodies of water. The purpose of this study was to evaluate the sub lethal effects of CYP on behavioral and morphological indices of *Oreochromis niloticus*, a common African indigenous tropical freshwater cichlid that is prevalent and in high demand.

Materials and Methods

Test fish and experimental pesticide

Juveniles of *Oreochromis niloticus* (weight: 35.43 ± 0.12 g; length: 13.45 ± 1.32 cm) were obtained from Kubani Dam Ahmadu Bello University, Zaria and transported to the fisheries laboratory of same university in a portable well aerated polythene bag containing water. The fish were acclimatized for two weeks in 160L capacity water bath containing dechlorinated municipal water and aerated to maintain optimum dissolved oxygen concentration. During the time of acclimatization, the fish were fed with commercial 4mm coppers fish feed (Afrimash, Lagos, Nigeria) containing 45% protein two times daily (9.00 h and 18.00 h).

Cypermethrin (CYP) was purchased from Comfort Agrochemicals, Zaria. A stock solution was formulated by dissolving 4 µg of the pesticide in one litre of distilled water from where sub-lethal concentrations used for the study were prepared. The sub-lethal concentrations (0.5 µg L⁻¹, 1.1 µg L⁻¹ and 2.1 µg L⁻¹) were determined by taking a fraction of 1/5, 1/10 and 1/20 respectively of the 96 h-LC₅₀ value (12.6 µg L⁻¹) previously obtained by Yaji *et al.* (2011). The sub-lethal concentrations of CYP were renewed every 48 hours with freshly prepared stock solutions.

Experimental design

Twelve aquaria tanks of equal size (30.5cm × 30.5cm × 46.25 cm) were used for the experiment. The test tanks were filled with 25L de-chlorinated municipal water where volumes of the stock solution were dispensed using micro-syringe, except in the control tanks. This was renewed every 48 h which helped to maintain toxicant strength and the level of dissolved oxygen, as well as minimize the level of ammonia during the experiment (Ogueji *et al.* 2018). The juveniles were exposed to sub lethal concentrations of toxicants for 8 weeks. The concentrations used for chronic study of the toxicant were 0.5 µg L⁻¹, 1.1 µg L⁻¹, 2.1 µg L⁻¹ and control (0.00 µg L⁻¹). Each treatment was in triplicate. Ten fish (25±0.52 g and 8.9±0.65 cm) each were randomly assigned to the tanks. Fishes were fed to 3% body weight and with commercial 4mm coppers fish feed (Afrimash. Lagos, Nigeria) containing 45% protein.

Behavioral and morphological assays

Behavioural and morphological responses of *O. niloticus* were observed at weeks 2, 6 and 8 during the chronic study according to Drummond *et al.* (1986). The control without toxicant exposure served as a guide for the evaluation of any behavioural changes in the treated tanks. Responses were registered if they differed from the controls and if they occurred in 10% of the fish. Monitored responses include: loss of equilibrium, abnormal mucus secretion, erratic swimming, air gulping activity, abnormal opercula ventilation and alteration of skin coloration. For 5-10 min, each test chamber was observed. Startle responses were tracked with a plastic applicator stick by gently touching the fish (tactile stimulus).

Results

Change in fish behaviour

Behavioural activities were normal in the control group and 0.5 µg L⁻¹ in the exposed group at weeks 2 and 6. Dose and duration-dependent abnormal changes characterized by loss of equilibrium, abnormal mucus secretion, erratic swimming, abnormal opercula ventilation, reduced air gulping activity, and change in skin coloration were observed in the CYP treated fish (Table 1). The three behavioural indices of erratic movement, opercular ventilation, and increased air gulping activity showed duration dependent moderate (10-50%) and strong (>50%) responses in the highest sub lethal concentration (2.1 µg L⁻¹) in weeks 2 and 6. However, in week 8 and at the same sub lethal concentration, the responses became weaker (Table 1). In week 2, at 1.1 µg L⁻¹, the mucus secretion was normal while there was no alteration in skin colouration but at higher exposure periods viz week 6 and 8, the treated fish showed mild and moderate responses respectively to those behavioural indices. Each test tank was observed for 5-10 min.

Table 1: Effect of CYP on behavioural indices of *O. niloticus* at different exposure durations

Conc. ($\mu\text{g L}^{-1}$)	Loss of Equilibrium	Abnormal mucus Secretion	Erratic swimming	Air gulping activity	Abnormal opercula ventilation	Change in skin coloration
2wks						
Control	-	-	-	-	-	-
0.5 $\mu\text{g L}^{-1}$	-	-	-	-	-	-
1.1 $\mu\text{g L}^{-1}$	-	-	+	+	+	-
2.1 $\mu\text{g L}^{-1}$	+	+	++	++	++	+
6wks						
Control	-	-	-	-	-	-
0.5 $\mu\text{g L}^{-1}$	-	-	-	-	-	-
1.1 $\mu\text{g L}^{-1}$	+	+	++	++	++	+
2.1 $\mu\text{g L}^{-1}$	++	++	+++	+++	+++	++
8wks						
Control	-	-	-	-	-	-
0.5 $\mu\text{g L}^{-1}$	-	-	+	+	+	+
1.1 $\mu\text{g L}^{-1}$	+	++	+	++	++	++
2.1 $\mu\text{g L}^{-1}$	++	+++	++	++	++	+++

None (0%); + Mild (<10%); ++ Moderate (10–50%); +++ Strong (>50%).

Discussion

Behavioral responses to CYP sub-lethal exposure

From the outcome in Table 1, CYP mediated dose and duration dependent behavioral changes in *O. niloticus* juveniles characterized by loss of balance, irregular swimming, abnormal secretion of mucus, abnormal breathing of the opercula, increased activity of air gulping, and change in coloration of the skin. Inconstant swimming pattern with jerky movements and some fish suspended in vertical position with tail pointing downward, characterized the responses in the highest concentrations of weeks 2 and 6. This behavior suggests that treated fish have resorted to increased air gulping, possibly to obtain oxygen for higher metabolic rates and energy required for detoxification of CYP. In week 8, the subsequent slowed/moderate swimming movement and opercular ventilation were characterized by a loss of equilibrium and few fish sinking to the bottom of the tank, becoming motionless and some fish dying subsequently. Our finding is consistent with Ullah *et al.* (2015), who reported that jumping, abrupt swimming, loss of balance/equilibrium, increased surface activity and air gulping were behavioural alterations correlated with exposure of *Tor putitora* fry to acute CYP. In the 1.1 $\mu\text{g L}^{-1}$ and 2.1 $\mu\text{g L}^{-1}$ sublethal doses of week 8, moderate (10-50%) and strong (>50%) responses were reported. The skin colour of the handled fish gradually changed to a glossy gray colour. Dispersion of pigment cells in chromatophores induced by CYP may have caused the observed color change. As a protective mechanism to shield fish from toxic impact, the mucus may be secreted. However, by hindering ion control and gas exchange in the gill epithelium, increased mucus, particularly in the gills, contributes to asphyxiation. Similar phenotypic answers have been recorded by other investigators (Ogueji *et al.* 2019, Akinsorotan *et al.* 2019).

Conclusion

The present study revealed that there was dose and duration dependent and also biphasic responses elicited by sub lethal concentrations of CYP on the behavioural and morphological indices of *O. niloticus*. To guard against this in the aquatic ecosystems, especially on non-target species, the application of CYP on farmland should be controlled.

References

- Akinsorotan, A. M., Ajisodun, A. F., Izah, S. C. and Jimoh, J. O. (2019). Acute Toxicity of Paraquat Dichloride on Fingerlings of *Oreochromis niloticus*. *International Journal of Research Studies in Biosciences*, 7(1): 29-36.
- Charles, R. and Hance, R. J. (1968). A World Compendium Crop Pesticides Constituent's Technical Data - British Crop Protection Council. 203 - 233.
- Drummond, R. A., Russom, C. L., Geiger, D. L. and DeFoe, D. L. (1986). Behavioral and Morphological Changes in Fathead Minnow (*Pimephales promelas*) as Diagnostic Endpoints for Screening Chemicals According to Mode of Action. *Aquatic Toxicology and Environmental Fate* edited by T. M. Poston and R. Pruddy: 415–435. STP 921. West Conshohocken: American Society for Testing and Material.
- Jensen, E. G., Skaare, J. U., Egaas, E. and Goksøyr, A. (1991). Response of Xenobiotics Metabolizing Enzymes in Rainbow Trout (*Oncorhynchus mykiss*) to Endosulfan, Detected by Enzyme Activities and Immunochemical Methods. *Aquatic Toxicology*, 21(1-2): 81-91.
- Lindsay, S. W. and Martens, W. J. M. (1998). Malaria in the African highlands: Past, present and future. *Bulletin of the World Health Organization*, 76(1):33-45.
- Ogueji, E. O., Nwani, C. D., Mbah, C. E., Nweke, F. N. (2019). Acute Hematological Toxicity of Ivermectin to Juvenile *Clarias gariepinus*. *Toxicological and Environmental Chemistry*, 101(3-6): 300-314.
- Seth, N. and Saxena, K. K. (2004). Hematological Responses in a Freshwater Fish *Channa punctatus* due to Fenvalerate. *Bulletin of Environmental Contamination and Toxicology*, 71(6): 1192-1199.
- Srivastava, N. and Kaushik, N. (2001). Use of Fish as Bio-indicator of Aquatic Pollution. *Proceedings of the International Congress of Chemistry and Environment* (ed. S.L. Gargh). 227–229.
- Ullah, R., Zuberi, A., Naeem, M. and Ullah, S. (2015). Toxicity to Hematology and Morphology of Liver, Brain and Gills during Acute Exposure of Mahseer (*Tor putitora*) to Cypermethrin. *International Journal of Agriculture and Biology*, 17(1): 199–204.
- Yaji, A. J., Auta, J., Oniye, S. J., Adakole, J. A. and Usman, J. I. (2011). Effects of cypermethrin on behavior and biochemical indices of fresh water fish *Oreochromis niloticus*. *Electronic Journal of Environmental, Agricultural and Food Chemistry*, 10 (2): 1927-1934.

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Histological Changes in Liver and Gills of *Periophthalmus Barbarus* (Mudskippers) Exposed to *Adhatoda bucculzii* Plant Extracts

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Abstract

Histological changes in the gills and liver of *Periophthalmus barbarus* exposed to *Adhatoda bucculzii* plant extracts were carried out. *P. barbarus* of mean weight ($20.0\text{g} \pm 0.22\text{SD}$) and length ($18.40\text{ cm} \pm 0.00\text{SD}$) were exposed to five concentrations: 0.00 mg/l (T1), $8.35 \times 10^{-4}\text{ mg/ml}$ (T2), $1.67 \times 10^{-3}\text{ mg/ml}$ (T3), $2.51 \times 10^{-3}\text{ mg/ml}$ (T4) and $3.34 \times 10^{-3}\text{ mg/ml}$ (T5) of *Adhatoda bucculzii* plant extracts for 96 hours. The exposed fish exhibited behavioural abnormalities such as loss of reflex, restlessness, high rate of opercular beats, abnormal swimming (vertically) and mortality with increasing concentrations of the plant extracts. The histology of the test fish revealed changes in gills structures which included fused lamella with hypertrophic and hyperplastic cells, cellular degeneration of the inter-lamella cells, nuclear condensation of the pillar cells, cellular degenerations of the pillar cells. While alterations observed in the liver tissues of the experimental organisms include presence of necrosis and congestion of the central veins. The study therefore revealed that exposure of *P. barbarus* to *A. bucculzii* extracts, had a toxic effect on the test organism with increasing concentration, beyond 0.33mg/l . therefore, application of *A. bucculzii* extracts in the aquatic environment should be done with caution to avoid the risk of indiscriminate destruction of the organism in the ecosystem.

Keywords: Mudskippers, Aquatic environment, Tissues, Toxicology

Introduction

Aquatic animals are good bio-monitors because chemicals that cause endocrine imbalances are rapidly absorbed through the gills and stored in the body (Saidu and Adams, 2017). Biological indicators are necessary in detecting environmental degradation and in assessing the success/or progress of river restoration project. Fish are sensitive to a wide variety of chemicals and toxic conditions in the aquatic environment which may cause decreased growth, alterations in physiological processes, and ultimately death (Yusuf and Olufayo, 2019). The use of histopathological techniques to investigate pollution effects is on the increase. Some pollution scientists have related the amount of cell damage in organisms to the concentration of a pollutant or the synergistic effect of more than one toxicant or both (Kori-Siakpere *et al.*, 2010). According to them also, histological alterations represent time-integrated impacts of both internal and external stimuli acting on an organism originating from alterations at the molecular level of biological organization. Histology thus acts as an integrated parameter providing a more complete evaluation of the organism's health than a single biomarker, effectively mirroring the effects of exposure to a plethora of environmental pollutants (The *et al.*, 1997).

The exposure of fish to any stress induces a number of modification in different organs particularly gills, liver, gonad. These organs play a major role in metabolism and have a number of functions in the body, including glycogen storage, decomposition of red blood cells, plasma protein synthesis, hormone production, and detoxification (Eitokpah, *et al.*, 2018). Tissue changes in test organism exposed to a sub-lethal concentration of toxicant are a functional response of organisms, which provides information on the nature of the toxicant. As an indicator of exposure to pollutants, histology represents a useful tool to assess the degree of pollution, particularly for sub-lethal and chronic effects (Okori-Siakpere *et al.*, 2010). According to Nwankpa, 2016, several research interest have recently shifted to medicinal plants and their potent and efficacious phytochemical compositions. The use of *Adhatoda bucculzii* plant extract in the capture of *P. barbarus* is a direct introduction of a pollutant in a water body. It was against this background that it became necessary in the present study, to determine the histological effects of acute toxicity of *A. bucculzii* plant extract on *P. barbarus*.

Materials and Method

One hundred and fifty live adult of *P.barbarus* were procured from fishermen in Ogbogoro station of the New Calabar River, moved to the laboratory of NIOMR/ARAC in Buguma, Rivers State, Nigeria. The fish were acclimated for seven days prior to the commencement of the experiment in a netted happa with a mud at the bottom and floating materials which provide a resting terrestrial platform for the fish. The fish were fed with pieces of crabs. They were fed two times daily (9am and 4pm). Ten fish were placed in each of the fifteen aquarium tanks for the experiment. One aquarium served as control with only water, while the remaining four were treated with the plant extract and this was Triplicated, the plant extract was obtained by adding 3.0 litre of water to 0.5kg of mashed plant. 0.0ml, 0.1ml, 0.2ml, 0.3ml and 0.4ml representing 0.0mg/l, 8.35×10^{-4} mg/m, 1.67×10^{-3} mg/ml, 2.51×10^{-3} mg/ml and 3.34×10^{-3} mgm/l respectively.

Water Quality Maintenance

Water quality parameters were monitored before introduction of the experimental organisms into the aquarium tanks. The parameters that were measured are temperature, salinity, hydrogen ion concentration (pH) and dissolved Oxygen (DOs). This was done to make sure that the water quality standards are maintained. Water temperature was taken by using mercury in glass thermometer, and the hydrogen ion concentration (pH) by pH meter (Mettler 340). Dissolved Oxygen Concentration was determined using an Oxygen meter (Oxyguard Handy MK II type) and their means calculated.

Histological Examination

After exposure time of 96hrs, samples of liver and gills were collected from the control (untreated) and treated groups for histological examinations. Gills and liver tissues were removed and fixed in 10% buffered formalin. After fixation for 24-30 hours, the tissues were washed for 2 hours with a running tap water in a beaker. The tissues were then dehydrated in graded series of alcohol solutions of 30,50,70,95, and 100% for 30 minutes each (Kori-Siakpere, et al., 2010). Tissues were cleared twice in xylene, infiltrated and embedded in paraffin wax. Sections of 5µm were then prepared from paraffin blocks by using a rotary microtome. Each section was mounted on a slide, stained with Haematoxylin and counter stained with eosin for light microscopic examination (Bloom and Fawcett, 1975, Roberts, 1978). Each tissue sample was examined for the presence of histological lesions. Stained sections examined for histological lesions were photographed, using an Olympus BHZ Photomicroscope. Photomicrographs of control and exposed tissues were made at X400 magnification for the purpose of comparison.

Results

Section of fish liver exposed to 0.00mg/ml of *A.bucchulzii* plant extract extracts showing normal sinusoid and fat cells consistent with normal histology of the liver are presented in Plate 1. While the section of fish liver exposed to 8.35×10^{-4} mg/ml of *A.bucchulzii* plant extract showing sinusoid and fat cells consistent with normal histology of the liver is shown in Plate 2. Moreover, the section of fish liver exposed to 1.67×10^{-3} mg/ml of *A.bucchulzii* extract showing sinusoid, fat cells and central vein (Plate 3). Hepatocytes are prominent in some areas. Histology is consistent with normal histology of the liver. Also, section of fish liver showing exposed to 2.51×10^{-3} mg/ml of *A.bucchulzii* extract sinusoid, fat cells and central vein (Plate 4). Hepatocytes are prominent in some areas with area of necrosis and congestion of the central vein. Histology is consistent with hepatocyte toxicity. Section of fish liver exposed to 3.34×10^{-3} mgm/l of *A.bucchulzii* extracts showing sinusoid, fat cells and central vein (Plate 5). Hepatocytes are prominent in some areas with area of necrosis. Histology is consistent with hepatocyte toxicity.

The gill of fish exposed to 0.00mg/ml of *A.bucchulzii* extracts are presented in Plate 6. A normal aspect of the gill showing the primary lamella, inter-lamella cells, pillar cells, mucous cells, epithelial cells and chloride cells consistent with normal gill histology. Also, the Gill of *P.barbarus* exposed to 8.35×10^{-4} mg/ml of *A.bucchulzii* extract (Plate 7) indicated a normal aspect of the inter-lamella space showing smooth muscle consistent with normal histology. The gill of *P.barbarus* exposed to 1.67×10^{-3} mg/ml of *A.bucchulzii* extract is shown in Plate 8. Section of the gills showing fused lamella with hypertrophic and hyperplastic cells consistent abnormal histology of the gills. There is also cellular degeneration of the inter-lamella cells. Gill of *P.barbarus* exposed to 2.51×10^{-3} mg/ml of *A.bucchulzii* extract (Plate 9) a section of the gills showed thickened basement membrane, hypertrophy and hyperplasia of the inter-lamella and nuclear condensation of the pillar cells consistent with abnormal histology of the gills. Gill of *P.barbarus* exposed to 3.34×10^{-3} mgm/l of "*A.bucchulzii*" extract are presented in Plate 10, a section of gills consistent with cellular degeneration of the pillar and chloride cells.

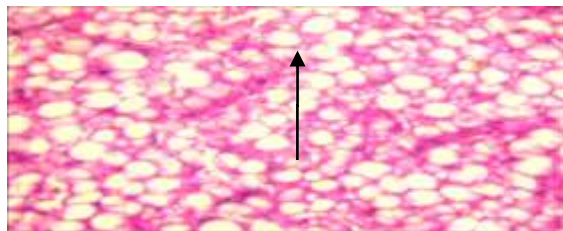


PLATE 1: T1 LIVER (x400)

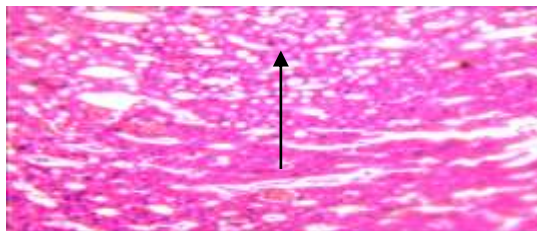


PLATE 2: T2. LIVER (x400)

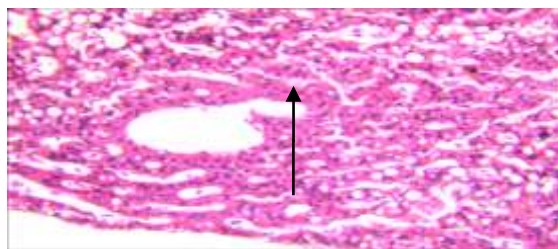


PLATE 3: T3. LIVER (x400)

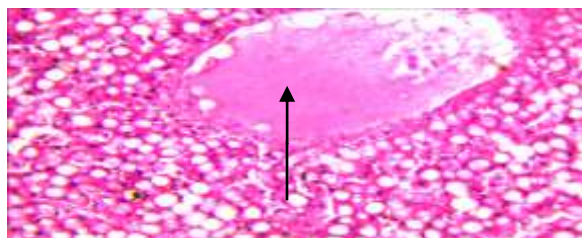


PLATE 4: T4-LIVER (x400)

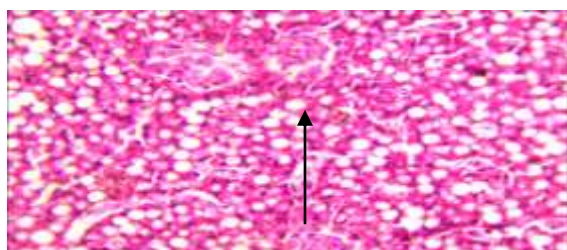


PLATE 5: T5 LIVERx 400

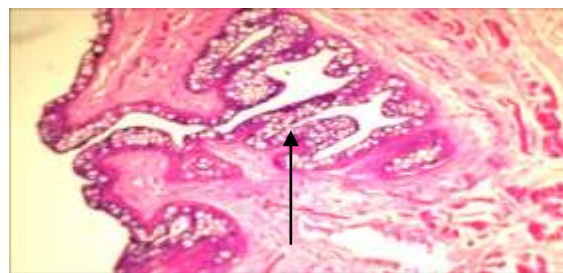


PLATE 6: T1. GILLS (x400)



PLATE 7: T2. GILLS (x400)

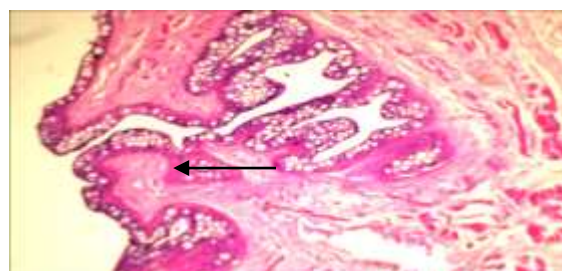


PLATE 8: T3. GILLS (x400)

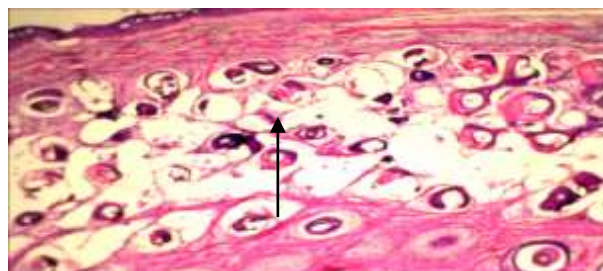


PLATE 9: T4. GILLS (x400)

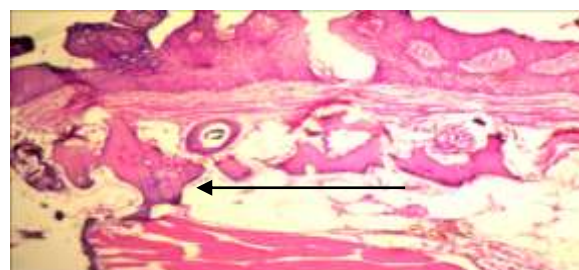


PLATE 10: T5. GILLS (x400)

Discussion

The experimental organisms showed erratic swimming motion loss of reflex vertical swimming and discolorations before dying. These are indication of physiological stress which must have lead to the observed mortality. The abnormal behaviours were concentration dependent as they increased with an increase in concentration of the extract. The mortality rate which is directly proportional to the concentration of the “Ogwaru” extract is also time dependent. The abnormal behavior did not occur in the control. Hence the mortality is attributed to the introduced plant extract. Normal liver architecture was seen in liver of control fish (00.0mg/ml), while some pathological alterations, necrosis and congestion of the central vein were seen in liver of T4 & T5 (2.51×10^{-3} mg/ml and 3.34×10^{-3} mg/ml respectively). Histology of liver exposed to 2.51×10^{-3} mg/ml and 3.34×10^{-3} mg/ml were consistent with hepatocyte toxicity which could not manifest in liver of T1 – T3 (0.00mg/ml, 8.35×10^{-4} mg/ml and 1.67×10^{-3} mg/ml respectively). The congestion of the central vein and presence of area of necrosis in liver exposed to T4 and T5 observed in this study was as a result of liver sensitivity to the toxicant (*A. buchuizii* extract). Akinsorotan (2014) reported same result in *C. gariepinus* fingerlings exposed to acute toxicity of dizensate (Glyphosate herbicide). However there was evidence of advancing phase of hepatocyte necrosis in *C. gariepinus* juveniles exposed to phostoxin (Yusuf & Olufayo 2019). Exposure of *P. barbarus* to sub-lethal concentration of *A. buchuizii* plant extract beyond 96hrs in 2.51×10^{-3} mg/ml and 3.34×10^{-3} mg/ml concentrations and more, may therefore inflict high noticeable pathological changes in the hepatocyte.

The gill of fish exposed to varying concentration of *A. buchuizii* plant extract showed severe erosion in the gill filament and degeneration of the gill lamellae with increasing toxicant concentration as well as loss of epithelial cells. These findings agreed with the reports of Yusuf and Olufayo, (2019) who reported same in *C. gariepinus* exposed to phostoxin. In the present study, T1 and T2 gills (exposed to 0.00mg/ml and 8.35×10^{-4} mg/ml respectively) presented normal gills showing the primary lamella, inter-lamella cells, pillar cells, mucous cells, epithelial cells and chloride cells consistent with normal gill histology. Whereas T3, T4 and T5 (1.67×10^{-3} mg/ml, 2.51×10^{-3} mg/ml and 3.34×10^{-3} mg/ml respectively) treated gills presented gills with fused lamella with hypertrophic and hyperplastic cells, nuclear condensation of pillar cells and cellular degeneration of the pillar and chloride cells. These features are consistent with abnormal histology of the gills. Toxicity of the toxicant on gills of *P. barbarus* increased with increasing concentrations.

Conclusion and Recommendations

The study revealed the Ichthyotoxic property of *Adhatoda buchuizii* (Ogwaru) plant on the histology of liver and gills of *P. barbarus*. The plant extract induced lesions, congestions, erosion and other pathological changes that characterized abnormal liver and gill with increasing concentrations. The use of this piscicidal plant near water bodies should be done with caution, as toxicity could destroy the vast population of plant and animal lives in water thereby destroying the entire aquatic food chain.

References

- Akinsorotan, A.M (2014); Toxicity of dizensate (Glyphosate herbicide) on *Clarias gariepinus* fingerling. Advanced Research in Biological Sciences. 2(1):1-5.
- Bloom, W. & Fawcett, D.W (1975). *A textbook of Histology*. Philadelphia: W.B Sanders Co.
- Eitokpah, E.P & Bassey, O.B (2018). Assessment of Heavy metal pollution in *Clarias agboyiensis* and *Synodontis clarias* in Ekpe and Lekki Lagoons, Lagos State, Nigeria. Proceedings on the 32nd Annual Conference of Fisheries Society of Nigeria. (FISON). Pp 195-199.
- Nwankpa, K.I (2016). The histological evaluation on the effects of *Moringa oleifera* leaf meal inclusions on the Liver and Ovaries of female *Oreochromis niloticus*. Nigerian Journal of Fisheries volume 13 numbers (1 & 2). Pp 1077-1084.
- Okori-Siakpere, O; Ikomi, R.B & Ogbe, M.G (2010). Histopathological Effects of Sublethal concentrations of potassium permanganate on the African Catfish: *Clarias gariepinus* (Burchell, 1822). *Journal of Aquatic Sciences* 25(1)73-84.
- Roberts, R.J (1978). *Fish pathology*. 1st ed. Bailliere Tindall, London, pp 67-70.
- Saidu, I & Adams, G.A (2017). Fish as Bio-indicator for Assessment of Aquatic Environmental Pollution in Lake Alau, Bornu State, Nigeria. Proceedings on 31st Annual Conference of Fisheries Society of Nigeria. (FISON). Pp 288-291.
- Teh, S.J, Adams, S.M., & Hinton, D.E (1997). Histopathologic biomarkers in feral fish populations exposed to different types of contaminant stress. *Aquatic Toxicology*, 37:51-70.

Yusuf, H.O & Olufayo, M.O (2019). Histological effects of phostoxin on catfish juveniles. Proceedings of 33rd Annual Conference of Fisheries Society of Nigeria (FISON).

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Abattoir Wastes In Niger Delta: A Review Of Its Impact on Water Quality**Akankali J.A., Chukwudi Chiamaka Faith and Davies, I. C.**Department of Fisheries, Faculty of Agriculture
University of Port Harcourt, P.M.B. 5323, Port Harcourt, Nigeria.*Corresponding Author: justin.akankali@uniport.edu.ng**Abstract**

The Niger Delta Region comprises of the biggest mangrove forest known in the world, these mangroves forest act as a breeding ground for most aquatic organisms. It is therefore important that the water quality of the region's water bodies are maintained against pollutants from various anthropogenic activities, including that resulting from solid wastes and effluents from abattoirs located in the region. Abattoirs in recent times as a result of population growth are commonly located in Niger Delta region along the banks of Creeks, Streams, Rivers and other surface water bodies, especially within the urban settlements. Consequently, most of these water bodies physicochemical parameters (pH, DO, BOD, Salinity, Turbidity, Transparency, odour etc.) have become adversely impacted by the organic pollutants arising from indiscriminate disposal of untreated Abattoir wastes into them. Thus, this paper reviewed the impacts of Abattoir wastes on the water quality of the region and recommend ways the impacts could be abated.

Keywords: Aquatic pollution, Water quality, Niger Delta, Wastes

Introduction

The Niger Delta Region is known for its vast area of land covered with water, majority of people living around the Niger Delta Region depend on these water bodies for their day-to-day activities and survival. The major occupation of individuals living in these regions is fish farming; they supply the country with different fish species, especially those species that are not easily cultured; which in turn grows the nation's economy.. Abattoir effluent contains high levels of organic matter due to the presence of manure, blood, fats, grease, hair, grit, and undigested feeds (Kosamu *et al.*, 2011; Magaji, 2000). These materials when discharged in open water bodies as is the case within the Niger Delta region definitely results in extensive water quality deterioration. In Nigeria, nearly every town and neighborhood are provided with a slaughter house or slaughter slab. Edwards *et al.* (1979) observed that abattoirs can be found in urban, rural and nominated industrial sites, and with their different advantages and disadvantages. Abattoir in the meat industries requires over 2000Gm³ of water per year for animal production and processing (Mekonnen and Hoekstra 2011, Angelakis *et al.*, 2015). The high volume of water required for meat production is equivalent to the amount of waste water produced which are discharged into different water bodies (Ayotunde *et al.*, 2019). This abattoir waste contains several compositional elements such as potential pathogens, bio- degradable organic compounds and odor producing elements (Alfonso-Muniozguren *et al.*, 2018; Eryuruk *et al.* 2018a and 2018b; Ozdemir, *et al.*, 2018). With the current level of discharge of such substances form Abattoirs in the waters of Niger Delta Region, the extent of pollution resulting in water quality deterioration is enormous within the region. The pictures in plates 1a and b showing Abattoirs with wastes along the shores of water bodies in two different locations in urban settings of Niger Delta is quite typical of virtually all Niger Delta urban settlements.



Plates 1a and b: Abattoirs with wastes along the shores of water bodies in Niger Delta Region
Abattoir wastes and It's Impact on Water quality in Niger Delta Region

Some studies have been carried out in some key states of the Niger delta Region on the impact of Abattoir wastes on the water quality of some water bodies. Delta and Rivers state are typical Niger Delta States in this regard, with the results of the studies indicating an adverse effects in parts of the water quality in the mediums of study. Emeribe *et al* (2016) reported that Anwai River in Delta state showed that in the downstream which is 5 meters from the slaughter house has been seriously polluted especially during the rainy season. The downstream; physicochemical values during rainy season for slaughter days recorded the highest level in all the parameters investigated when compared with the dry seasons notwithstanding the entrance of fresh water from the atmosphere. Another study carried out at the Trans-Amadi Creek in River state based on Godspower *et al*, (2019) report, showed that during the rainy season the waste generated are disposed or washed into the river which affected the water parameters measured negatively. The physicochemical parameters measured in both locations include BOD, COD, conductivity, pH, Alkalinity, TSS, TDS, DO, phosphorus, Nitrate etc. Generally it was discovered that abattoir effluent has adversely impacted the water bodies negatively making it unfit for human activities and also the living organisms dwelling in it. Aniebo *et al* (2009), reported that in Rumueme Abattoir, as in most other slaughter slabs in Rivers state, the entire blood and stomach contents were directly discharged into nearby New Calabar River. This improper disposal of abattoir blood and other wastes might produce death of aquatic organisms, and render such water bodies unfit for human use with attendant economic losses and health problems, as they percolate into underlying aquifers and contaminate nearby wells.

Impact of Abattoir Wastes on Some Physicochemical parameters of water in the Niger Delta Region

pH: According to the research done by Egobueze *et al* in (2012) at the Aleto River in Rivers state it was discovered that the pH of the water body was generally acidic. The mean pH value of 5.90 (range 5.13 – 6.82) was recorded and this value is below the ambient water quality criteria (6.5 – 8.50) recommended by both national and international bodies (WHO 1984; FEPA, 1991). The pH range recorded in this study indicates that the water was generally acidic. The more sensitive a species, the more affected it is by changes in pH. In addition to biological effects, extreme pH levels usually increase the solubility of elements and compounds, making toxic chemicals more “mobile” and increasing the risk of absorption by aquatic life.

Total suspended solid (TSS): Fresh Abattoir effluent (waste water) is mainly composed of diluted blood, fat and it may also contain some coarse solids e.g., manure, pieces of meat etc. They have been shown also to contain solids, minerals, metals, and micro-organisms. The high level of TSS discharge into the river increases the turbidity of water and causes a long-term demand for organic oxygen because of the hydrolysis rate of the organic fraction of the materials. Increase in TSS causes decrease in water body to support a diversity of aquatic life. Suspended solids absorb heat from sunlight, which increase water temperature and subsequently decrease levels of dissolved oxygen. Suspended solids can also harm fish directly by clogging gills, reducing growth rates, lowering resistance to disease, and movement of aquatic population is disrupted. (Chapman, 1997). In the Niger Delta region the practice of disposing fresh Abattoir into surface water bodies is a continuous and the dominant practice. This because most solid wastes and effluents are channeled into the water running along the banks of the creeks, streams or rivers where the Abattoirs are located as soon as they are generated. Consequently, it adversely impacts the water quality as opined in the preceding report by Chapman, (1997).

Total dissolved solids (TDS): Most aquatic organisms tolerate TDS of 1000mg/L. (Eze and Eze 2018). Egobueze *et al*, (2012) reported concentrations of total dissolved solids in Aleto river exposed to Abattoir waste to be in the range of 54 - 64.0 mg/l in the dry season and decreased to 33.67 – 55.24 mg/l in the rainy season. The level of TDS in a broad sense reflects the pollutant burden of the aquatic system. High levels of dissolved and suspended solids in the water systems increase the biological and chemical oxygen demand, which deplete the dissolved oxygen levels in the aquatic systems. The concentration of total dissolved solid was quite higher in the dry season compared to values obtained in the rainy season.

Conductivity: The WHO has set a maximum permissible level of the conductivity to be 1200 μ S/cm. Any level above this can pose health risk of defective endocrine functions and also total brain damage with prolonged exposure (Hunter *et al.*, 2009b). Egobueze *et al* (2012) reported conductivity value range results from Aleto River was from 77.30 μ S/cm to 131.10 μ S/cm. The dissolved solids and ion were introduced into surface water bodies from municipal run off, wastes from slaughter house and other anthropogenic sources. Significant changes in conductivity could then be indications that a discharge or some other source of pollution has entered a River. (Eze and Eze 2018).

Phosphate and Nitrate: The faeces of livestock has been observed to consist of undigested food, mostly cellulose fibre, undigested protein, excess nitrogen from digested protein, residue from digested fluids, waste mineral matter, foreign matter such as dirt consumed, calcium, magnesium, phosphorus, sodium, etc. which can cause nutrient-over enrichment of the water body (eutrophication) (Ezeoha and Ugwuishiwu, 2011). Abattoir effluent causes excess phosphorus and nitrogen in rivers which causes eutrophication (excessive vegetative growth) which could reduce the size of receiving stream channels, which could cause over-flooding and its consequent damages. The mean concentration of phosphate and nitrate in Aleto River was 0.10 mg/l and 1.05 mg/l NO₃-N respectively which is significantly lower than FEPA water quality criteria of 0.5 mg/l and 10.0 mg/l. At Station 1, this is the discharge point of the abattoir sludge into the river showed highest concentration of NO₃-N. (Egobueze *et al* 2012)

Dissolved oxygen: DO is significant in the protection of aesthetic qualities of water, maintenance of water temperature, the quantity of sediment in the stream, the amount of oxygen taken out of the system by respiring and decaying organisms, and the stream flow, and the amount of oxygen put back into the system by photosynthesizing plants, of any organic materials present, which causes noxious gases, such as corrosion in water pipes. Low level of dissolved oxygen (DO) and ammonia toxicity in such streams could result in death of fish. (Ezeoha and Ugwuishiwu, 2011).

Odour: Fresh Abattoir effluent is mainly composed of diluted blood, fat and suspended solids, minerals, metals, and micro-organisms, as they begin to decompose these abattoir effluents is often malodorous. In most abattoirs in Nigeria, both the paunch manure and the animal faeces are allowed to pile up and decompose without necessary attention. Such manure piles are permanent sources of pollution within the market environment, as they are often foul-smelling, attract both flies and scavengers and breed mosquitoes. (Ezeoha and Ugwuishiwu, 2011) The Orogodo River in Delta State had an objectionable colour and odour due to the direct dumping of raw blood, fresh and decaying flesh as well as dung from the abattoir into the receiving river without any form of treatment and this process reduces the aesthetic and portability values of the water. (Godwin Asibor 2019)

Colour: Abattoir effluents when washed down into the water affect the colour of the water body. They in turn affects the turbidity of the water which reduces the amount of sunlight entering the water body. Some fish species are known to live in clear and non-polluted environments are affected and are forced to migrate to another body of water. (Ezeoha and Ugwuishiwu 2016). Most surface waters exposed to Abattoir wastes within Niger Delta have highly undesirable colours.

Turbidity: Turbidity in drinking- water is caused by particulate matter that may be present from water source as a consequence of inadequate filtration. These particulates can protect microorganisms from the effects of disinfection and can stimulate bacterial growth (Hunter *et al.*, 2009a). Increases the turbidity of water causes a long-term demand for organic oxygen because of the hydrolysis rate of the organic fraction of the materials. Wastes discharged into surface water body within the Niger Delta region generally turns the waters to varying shades of dark colouration. These shade of dark colourations in water reduces light penetration in water, which in turns reduces photosynthetic activities of the phytoplankton in the water. Since phytoplankton are at the base of primary productivity, this phenomenon generally results low yield of fishes and other aquatic resources of economic importance from such water bodies.

Conclusion

Urbanization and population would continue to increase resulting in steady rise in consumption of meat. This will ultimately lead to more adverse impacts on water quality of Niger Delta region. The implication of this knowledge is that abattoir wastes should be properly treated, prior to it's being discharged into any water body. This would make the wastes amenable to stipulated effluent standards, odour control or to exploit the benefits locking in the wastes before safely and economically disposing the ultimate wastes. Awareness creation through sensitization of all critical stake holders is required for an attitudinal change that will help reduce the current Abattoir waste disposal practice in the region, that exacerbates it's adverse impacts on water quality. It is equally important that the relevant Agencies of Government in the region such as the states and Local Governments invest in modern Abattoir infrastructures and facilities across the region to help check the environmental menace of the current crude Abattoir practices prevalent in the region.

References

- Angelakis, A., Snyder, S., Angelakis, A. N., & Snyder, S. A. (2015). Wastewater treatment and reuse: Past, present, and future. *Water*, 7(12), 4887–4895. doi:10.3390/w7094887.
- Aniebo, A. O. , Wekhe, S. N. and Okoli, I. C.(2009) 'Abattoir blood waste generation in Rivers State and its environmental implications in the Niger Delta', *Toxicological & Environmental Chemistry*, 91: 4, 619 — 625
- Alfonso-Muniozguren, P., Lee, J., Bussemaker, M., Chadeesingh, R., Jones, C., Oakley, D., & Saroj, D. (2018). 'A combined activated sludge-filtration- ozonation process for abattoir wastewater treatment'. *Journal of Water Process Engineering*, (25), 157–163.
- Ayotunde Akanni, Adebajji Ogiye & Olumuyiwa Onakunle | (2019) The Impact assessment of abattoir waste facility discharge on water in Osogbo, Nigeria, *Cogent Engineering*, 6:1, 1614317
- Chapman, D. *Water Quality Assessment. A guide to the use of Biota, Sediments and Water in Environmental Monitoring*. Second Edition. E & FNSpon; London, UK. 1997.
- Egobueze, Francis & Iwegbue, Cma & Arimoro, Francis. (2012). Effect of abattoir wastes on the water quality of Aleto River in the Niger Delta, Nigeria. *Tropical Freshwater Biology*. 20. 10.4314/tfb.v20i1.7.
- Eryuruk, K., Tezcan Un, U., & Bakır Ogutveren, U. (2018). 'Electrochemical treatment of wastewaters from poultry slaughtering and processing by using iron electrodes'. *Journal of Cleaner Production*, 172, 1089–1095. doi:10.1016/j.jclepro.2017.10.254
- Ezeoha S. L, Ugwuishiwi B. O, 2011 'Status of abattoir wastes research in nigeria' *Nigerian Journal of Technology* Vol. 30, No. 2. June 2011
- Godwin Asibor (2019), Status Of Discharged Abattoir Effluent And Its Effects On The Physico-Chemical Characteristics Of Orogodo River, Delta State, *Nigeria International Journal of Environment and Pollution Research* Vol.7, No.3, pp.34-44, August 2019
- Hunter PR., Zmirou-Navier D, Hartemann P. (2009a). Estimating the impact on health of poor reliability of drinking water interventions in developing countries. *Science of the total Environment* 407, 2621-2624.
- Hunter PR., Pond K, Jagals P, Cameron J. (2009b). An assessment of the costs and benefits of interventions aimed at improving rural community water supplies in developed countries. *Science of the Total Environment* 407, 3681-3685.
- Mekonnen, M. M., & Hoekstra, A. Y. (2011). The green, blue and grey water footprint of crops and derived crop products. *Hydrology and Earth System Sciences*, 15 (5), 1577–1600. doi:10.5194/hess-15-1577-2011
<http://www.informaworld.com/smpp/content=9 713626332>
- Ozdemir, S., Yetilmezsoy, K., Nuhoglu, N. N., Dede, O. H., & Turp, S. M. (2018). 'Effects of poultry abattoir sludge amendment on feedstock composition, energy content, and combustion emissions of giant reed (*Arundo donax* L.)'. *Journal of King Saud University - Science*. doi:10.1016/j. jksus.2018.04.002
- WHO (1981) *Guidelines To Reduce Human Health Risks Associated Animals In Urban Areas*. VPH/81.29, World Health Organisation, Geneva.

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Physico-Chemical Parameters Of Dzwafini River, Patigi, Kwara State, Nigeria*** Ibrahim, B. U., Dadi-Mamud, N. J., Hussaini, H. M., and Hassan, M.A.,**Department of Biological Science, Faculty of Natural Science,
Ibrahim Badamasi Babangida University, Lapai, Niger State. Nigeria.
ibrahimsayuti@yahoo.com**Abstract**

This study determined the physico-chemical parameters of Dzwafini River at five different sampling stations (Patigi, Kparumagi, Gudugi, Esugi and Mandzakwa) the study was conducted in two seasons; dry season (February – May 2020) and rainy season (June – September 2020). The physico-chemical parameters were monitored using standard methods and procedures. The monitored physico-chemical parameters includes; temperature, pH, turbidity, transparency, total hardness, alkalinity, Biological Oxygen Demand, Dissolved Oxygen, Chloride, Phosphate NH_3 . There were fluctuation in the values of physico-chemical parameters based on months and stations and season. Parameters monitored were temperature, pH, turbidity, transparency, Total hardness, Alkalinity, Biological Oxygen Demand, Dissolved Oxygen, Chloride, Phosphate NH_3 . The results showed the range of various parameters: pH (6.16 ± 0.47 - 6.87 ± 0.16), Electrical Conductivity (49 ± 2.02 - 73.25 ± 9.6), Biological Oxygen demand (3.9 ± 0.64 to 5.15 ± 1.03), Total Alkalinity (20.37 ± 2.43 - 27.12 ± 3.71) pH, Electrical Conductivity, Biological Oxygen Demand (BOD) and Total Alkalinity were significantly different ($P < 0.05$) among all the sampling station, However, Dissolved Oxygen (7.00 ± 0.46 - 8.81 ± 0.63), Total Hardness (14.25 ± 0.95 - 21.62 ± 2.99) Nitrate (1.24 ± 0.16 - 3.16 ± 1.46) Turbidity (35.00 ± 3.01 - 54.37 ± 2.52 NTU), Total Dissolved solid (14.38 ± 1.56 - 18.50 ± 2.78), Transparency (12.62 ± 1.01 - 14.87 ± 1.45) Chloride ranged (11.39 ± 3.10 - 38.72 ± 12.26) Phosphate (0.44 ± 0.17 - 1.25 ± 0.54) and Temperature (25.5 ± 0.42 - 26.00 ± 0.53).

Keywords: Aquatic environment, Physico-chemical Parameters, Dzwafini River.**Introduction**

Water is an essential component for life on earth and its sources include rivers, streams, lakes, wells, boreholes, spring etc (Versari *et al.* 2002). Rivers are among the oldest water bodies in the world (Higler, 2012). The study of physico-chemical parameters of water is a basic aspect of limnology, which include the aspect of biological, chemical and physical characteristic and functions of inland water (this include the study of lakes, reservoir, pond river springs, streams wetland and ground water). The quality of a given water body is controlled by its physical, chemical and biological factors, all of which interact with one another to influence its productivity. In order to assess the productivity of such aquatic ecosystem for their essential management and effective utilization, there is the need to study these parameters with a view to controlling and maintaining them within optimum range (USEPA, 1989). Point and non-point source pollution are major environmental problems affecting water quality. The situation is worsened by lack of treatment for domestic wastes. In farming areas, the routine application of agricultural fertilizers is the major source of contamination Emongor (2005). In urban areas, the careless disposal of industrial effluents and other wastes may contribute greatly to the contamination and poor quality of the water Belay and Sahile (2013). The Dzwafini River is surrounded by fishing villages where fishing and other recreational activities were performed in the river. The villagers around this river are involved in fishing and agricultural activities where herbicides and pesticides are being used on the daily bases. They also used the river for other activities such as, bathing and washing of their clothes, pots and plates. All these activities are likely to alter the quality and portability of water in the river which may in turn affect the life of aquatic organisms as well is deteriorative to human life. However, the study seek to determine some physico-chemical parameters of Dzwafini River, Patigi, Kwara State, Nigeria.

Methodology**Study Area**

Dzwafini River is located 2km North of Patigi village about (163.7km) from Kwara state, Kwara State in the North East of Nigeria. The area cover Guinea Savanna Zone between Longitude 6°E and Latitude 35°N as shown in fig.1. Its vegetation combines the savannah grassland type of the north and middle belt with the tropical rain forest

type of the North East of Nigeria (F.C.D.A., 1979). Meteorological records have shown that rainfall start as late as April in some years and peak between October and November, annual rainfall of about 1000 – 1500mm have been recorded in Kwara State. Dry season begins in November and last till March. The season months of December and January are usually cold and dry due to the influence of the North- East winds which usher in the hamattan. There are two main seasons in Kwara State. These are the dry and wet seasons. The reservoir had a capacity of 400 million cubic meters of water and a surface area of 10, 000 hectares, The surrounding settlements of Dzwafini river majorly depend on agriculture as major source of livelihood (Ahmed *et al.*, 2012).

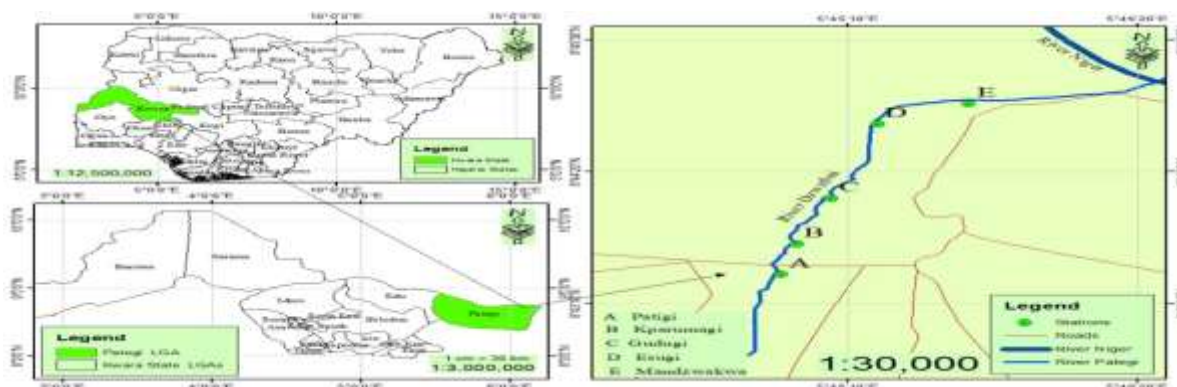


Fig 1: Map of Dzwafini River, Patigi, Kwara State, Nigeria, showing the sampling station

Experimental Design

The study was conducted for a period of eight months (February 2020 – September 2020). Five sampling station was identified based on proximity to Dzwafini River; Bimonthly samples were taken from February, 2020 to September, 2020.

Sample Collection

The method of collection, preparation and preservation was similar to those reported in previous studies and Standard methods was followed that listed by American Public Health Association (APHA, 2005; and APHA, 2012). Five sampling stations (Patigi, Kparumagi, Gudugi, Esugi and Mandzakwa) were established around the river bank. The name of each station represents the entry points of Major Rivers besides tributaries as well as the exit point. In a sterilized polythene bottles of one liter capacity. Samples was brought to the laboratory for other analysis of physico-chemical parameters like, Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Chloride, Ammonia Nitrogen, and Total Hardness, Total Alkalinity, Total Dissolved Solids. Monitoring was performed during February 2020 to September 2020 (dry and wet seasons). Water sample was collected in the morning (8:00am-10:00am). The physical parameters of the river were analyzed using standards methods recommended by APHA (2012). The parameters were compared according to Standard methods for water and waste water examination as described by APHA (2012 and 2005) was used.

Data analysis

Analysis of Variance (ANOVA) was used to test for significant differences in mean physico-chemical parameter and Duncan's Multiple Range Test (DMRT) was used to separate the means where significant differences exist among the sampling station.

Results and Discussion

The study of the physico-chemical parameters of water is a basic aspect of limnology, which include the aspect of biological, chemical and physical characteristic and functions of inland water (this include the study of lakes, reservoir, pond river springs, streams wetland and ground water. (Keke *et al.*, 2017). These studies however, evaluate the physico-chemical parameters including temperature, pH, turbidity, transparency, total hardness, alkalinity, BOD, dissolved oxygen, Chloride, Phosphate NH_3 etc.

Temperature is an important water quality parameter which determine the hotness and coolness of a given water body. The mean value of temperature ranged (27.4 ± 0.03 to 23.8 ± 0.41) for this study, which falls within the optimum temperature values of $25.0 - 32.0^{\circ}\text{C}$ which is normal for fish production and survival. The findings of this research are in agreement with the report of Olarewaju *et al.* (2017) who recorded 26.64°C in his study.

The water transparency and turbidity, the two related physical properties express the optical property and reflects the intensity of light present in the water. The turbidity determines the turbid nature of the river while transparency settles for ability to see clear through the water body. In this study, the turbidity values recorded ranged from 33.9 ± 10.31 to 10.6 ± 0.04 NTU. This is within the range of 35.50 NTU as reported by Keke *et al.* (2013). Low transparency was recorded during the study period. This might be attributed to the surface run-offs, turbulences and high turbidity which reduce the amount of light intensity penetrating the Reservoir. This is in conformity with the findings of Ibrahim *et al.*, (2009) in their study of Kontagora Reservoir, Niger State, and similar to what was reported for Alau Lake by Usman *et al.*, (2013), in Dadin-Kowa reservoir.

pH of the river determines the rate of hydrogen concentration in water, is an important parameter used to state whether acidic or alkalinity of water. The values obtained for pH ranged from 6.99 ± 0.04 to 5.63 ± 0.42 which falls within the values of 6.5-9.0 water pH stipulated by world quality standard for fish production (WHO, 1990; EPA, 2001). Adebowale *et al.*, (2008) state that any range outside this may affect fish productivity and other biological activities. Water pH in the range of 4.0 to 6.5 and 9.0 to 11.0, can cause stress in fishes and death is almost certain at a pH of less than 4.0 or greater than 11.0 (Ekubo and Abowei, 2011). While Olarewaju *et al.* (2017) reported slightly alkaline water (7.11) in Eleyele Reservoir which is similar to the report of this study. The pH concentration recorded in the present study compares favorably with other tropical Reservoirs (Ayoade *et al.*, 2006, Atobatele and Ugwumba, 2008, Ibrahim *et al.*, 2009).

Electric conductivity (EC) is a parameter that determines the extent to which water can conduct electric current. The values obtained for EC ranged from 109.9 ± 51.91 to 49 ± 2.59 ($\mu\text{S}/\text{cm}$) this agrees to the reported by Reuben *et al.* (2018), and negate the report by Olarewaju *et al.* (2017) who recorded lower value of $0.270 \mu\text{S}/\text{cm}$. The low EC values obtained in this may attributed to the fact that the river might contain more amount of suspended and dissolved solid materials, which increases the concentration of cation such as calcium, magnesium and sulphate (Mustapha, 2008; Arimoro *et al.*, 2015). Conductivity can be used as indicator of primary production (chemical richness) and thus fish production. Fish are known to differ in their ability to maintain osmotic pressure, therefore the optimum conductivity for fish production differs from one species to another (Bhatnagar and Devi, 2013).

The biochemical oxygen demand (BOD) is the measurement of total dissolved oxygen consumed by microorganisms for biodegradation of organic matter such as food particles or sewage (Bhatnagar and Devi, 2013). This study showed consistency in the BOD values which ranged from 6.33 ± 0.63 to 3.0 ± 0.6 (Mg/l). Dissolved oxygen ranged from 9.2 ± 0.8 to 7.12 ± 0.02 (Mg/l), this is an indication of moderately clean water. This finding is an indication of oxygenated water. (Bhatnagar and Devi, 2013). According to Bhatnagar and Singh (2010) and Bhatnagar *et al.*, (2013) DO level $>5\text{ppm}$ is essential to support good fish production. The values obtained for total dissolved solid (TDS) ranged from 9.25 ± 0.96 to 33.24 ± 7.76 (Mg/l). This agrees with the findings of Tukura *et al.*, (2012) in Mada River in Nasarawa, Nigeria. The levels of TDS in abroad sense reflect the burden of aquatic systems. Pandey *et al.*, (2012) reported that high dissolved solids in water could have organo-trophic implication and can cause suffocations to aquatic fauna and impair gill function.

Chloride Nitrate and Phosphate values recorded during the study period are indicators of different anthropogenic activities around the river. The influx run-offs from surrounding farm lands in some reaches of the stream are likely responsible for the perceived deterioration of the water quality. High Nitrate and phosphate content could be as a result of different anthropogenic activities and surface run off from farms and decomposition of organic matters into the water (Ibrahim *et al.*, 2009). To protect our water resources it is important to determine the factors that positively or negatively impact them which are the water physico-chemical parameters.

Table 1: Mean monthly Physico - chemical Parameters (February to September 2020) of River Dzwafini, Patigi Kwara State, Nigeria.

PARAMETERS	DRY SEASON				RAINY SEASON			
	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
pH	6.57±0.14 ^a	6.65±0.15 ^a	6.65±0.06 ^a	6.65±0.19 ^a	6.71±0.05 ^a	6.99±0.04 ^a	6.01±0.08 ^a	5.63±0.42 ^a
EC(μS/cm)	50.7±0.01 ^a	55.6±0.4 ^a	55.6±0.41 ^a	54.2±3.21 ^a	52.1±0.69 ^a	49±2.59 ^a	74.6±14.41 ^a	109.9±51.91 ^a
DO (mg/l)	7.12±0.02 ^a	7.95±0.45 ^a	7.95±0.45 ^a	9.2±0.08 ^a	7.56±1.04 ^a	7.6±0.48 ^a	7.7±0.61 ^a	8.37±0.03 ^a
BOD (Mg/l)	4.28±0.16 ^c	3±0.06 ^d	3±0.61 ^d	4±0.04 ^c	5.51±1.13 ^b	4.75±0.05 ^c	5.44±0.24 ^{bc}	6.33±0.63 ^a
TA (mg/l)	16.2±2.08 ^d	31.2±0.41 ^a	31.2±0.41 ^a	30.4±0.04 ^a	28±1.16 ^a	28±1.79 ^a	17.15±8.35 ^b	21±4.21 ^c
TH(g/l)	20±1.05 ^a	18.1±0.05 ^b	18.1±0.05 ^b	22.8±2.02 ^a	16.8±1.12 ^b	16±2.41 ^b	17.56±0.36 ^b	15.76±2.16 ^b
Ammonia nitrate(mg/l)	1.72±0.07 ^a	2.09±0.11 ^a	2.24±0.05 ^a	2.1±0.14 ^a	0.83±0.28 ^a	2.03±1.38 ^a	0.72±0.05 ^a	3.08±0.83 ^a
Chloride(mg/l)	46.31±1.26 ^b	61.59±1.58 ^a	61.59±1.58 ^a	56.09±2.19 ^a	3.41±0.28 ^b	3.88±0.42 ^b	3.58±0.29 ^c	3.82±0.06
TDS (mg/l)	13.72±1.04 ^b	17.96±0.35 ^a	17.57±0.04 ^a	17.64±1.33 ^a	3.41±0.28 ^d	13.89±0.2 ^b	6.79±3.88 ^c	17.56±0.26 ^a
Temperature °C	25.6±0.04 ^a	24.7±0.05 ^a	23.8±0.41 ^a	24.1±0.01 ^a	27.4±0.03 ^a	26±0.21 ^a	25.3±0.91 ^a	25.7±0.09 ^a
Transparency (m)	10.6±0.04 ^c	12.1±0.71 ^c	11.5±0.03	14.9±0.03 ^b	11.12±0.34 ^c	15.8±2.41 ^b	12.9±0.51 ^c	33.9±10.31 ^a
Phosphate (mg/l)	1.08±0.93 ^a	0.15±0.01 ^a	0.14±0.01 ^a	1.07±0.89 ^a	0.27±0.05 ^a	0.2±0.04 ^a	0.15±0.01 ^a	2.74±1.42 ^a
Turbidity (NTU)	40.9±2.32 ^b	31.5±5.07 ^c	40.1±2.01 ^b	39.9±0.05 ^c	46.5±0.09 ^b	54.7±3.11 ^a	42±2.02 ^b	42.5±9.51 ^b

* Values on a row with the same superscript are not significantly different (P<0.05)

Conclusion and Recommendation

The physiochemical parameters of Dzwafini River were analyzed at FUT and the values obtained were all within the recommended figure based on APH 2020. However, the parameters vary across the months and were all significant at P<0.05. Based on the outcome of this research of physicochemical parameters, the water is safe for used of public consumption and recreational purposes.

This study showed that the water quality parameters of rive Dzwafini is the recommended figure based on APH 2020 suitable for fish survival and production. Therefore, the government bodies and other civic organisation responsible for river and lake monitoring should take the action against releasing of domestic waste directly into the river or installed a water purification system

References

- Ahmad, I., Philip A.Q ., Bahadar, K., Hussain, U., Rehman, A., Iqbal, H., Wahab, A., Haq, A. U., Khan, M. A., and Ijaz, F. (2012). Physico-Chemical Analysis of Drinking Water Sources at Sampling Point of Billitang, Kda, Nasrat khel and Chongee of District Kohat, K.P.K., Pakistan. *International Journal of Science Innovations and Discoveries*, 2(6), 598-609
- Adebawale, K.O., Agunbiade, F.O. and Olu-Olowolabi, B.I. (2008). Impacts of natural and anthropogenic multiple sources of pollution on the environmental conditions of Ondo State Coastal Water, Nigeria. *Electronic Journal of Environmental, Agricultural and Food Chemistry*, 7(4): 2797-2811.
- APHA, (2005). American Water Works Association and Water Environment Federation, "Standard Methods for the Examination of Water and Waste water" (21st Ed). American Public Health Association, Washington DC, USA

- Arimoro F.O., Uhunoma, S.I., & Edegbene, A.O. (2015). Anthropogenic impact on water chemistry and benthic macroinvertebrate association change in a southern Nigeria stream. *Enviro Monitoring Assessment* 187, 1-14
- Atobatele, O. E. and Ugwumba, O. A. (2008). Seasonal variation in the physico-chemistry of a small tropical reservoir (Aiba Reservoir, Iwo, Osun, Nigeria). *African Journal of Biotechnology*. 7 (12):1962-1971
- Ayoade, A. A., Fagade, S. O. and Adebisi, A. A. (2006). Dynamics of Limnological features of two man-made lakes in relation to fish production. *Africa Journal. Biotechnology* 5 (10): 10131021.
- APHA, (2012). Standard methods for the examination of water and waste water. 19th edition. American Public Health Association Inc., New York, 1193
- Bhatnagar, A. and Devi, P. (2013). Water quality guidelines for the management of pond fish culture. *International Journal of Environmental Sciences*, (3): 6
- Ekubo, A. A. and Abowei, J. F. N., (2011). Review of some water quality management principles in culture fisheries. *Research Journal of Applied Sciences, Engineering and Technology*, 3(2), pp 1342-1357.
- Emongor, V.; Kealotswe, E.; Koorapetse, I.; Sankwasa, S.; Keikanetswe S. (2005) *Journal. Applied. Science*, 147
- EPA, (2001). Parameters of Water Quality: Interpretation and Standards .Environmental Protection Agency. Published by EPA Ireland pp 1- 132
- F.C.D.A., (1979): Final report, development of planning and survey of Federal Capital Development Authority, Abuja. 102.
- Higler, L. W. G. (2012). *Fresh surface water: Biology and Biodiversity of River systems, Encyclopedia of Life Support Systems (EOLSS), ALTERRA, Wageningen, The Netherlands*
- Ibrahim, B. U., Auta, J. and Balogun, J.K. (2009). An assessment of the physico-chemical parameters of Kontagora River, Niger State, Nigeria. *Bayero Journal of Pure and Applied Sciences*, 2(1): 64-69.
- Keke, U. N. Arimoro, F.O. Ayanwale, A.V. & Aliyu, S. M. (2015). Physicochemical parameters and Heavy content of Surface water in downstream Kaduna River, Zungeru, Niger State, *Applied Science Research Journal*, 3 (2), 46-47
- Mustapha, M. K. (2008). Seasonal Influence of Limnological Variables on Plankton Dynamics of a Small, Shallow, Tropical African Reservoir. *Asian J. Exp. Biol. Sci.* 1 (1): 60-79.
- Olanrewaju, A. N., Ajani, E. K., Kareem, O. K. & Orisasona, O. (2017). Relationship Between Parameters and Reproductive Indices of *Parachanna obscura* (Gynther 1816)b in Eleyele Reservoir, Ibadan, Nigeria. *European Journal of Experimental Biology*, 7 (6)
- Pandey, S. C., Singh, S. M, Pani, S. and Malhosia, A. (2012). Limnology: A Case Study Of Highly Polluted Laharpur Reservoir, Bhopal, (M.P.) India. *International Journal of Chemical, Biological and Physical Sciences*. Vol 2. No 3, 1560 – 1566.
- Tukura, B. W., Gimba, C. E., Ndukwe, I. G. and Kim, B. C. (2012). Physico-chemical Characteristics of Water and Sediment in Mada River, Nasarawa State, Nigeria. *International Journal of Environment and Bioenergy*, 1(3): 170-178.
- Usman, A., Solomon, S.G. and Okayi, R.G. (2013). Aspects of the biology of some selected fish species from Lake Alau, arid zone Nigeria. *Nigerian Journal of Fisheries and Aquaculture*, 2(1): 24 – 36.
- Versari, A., Parpinello, G.P. and Galassi, S. (2002). Chemo-metric survey of Italian bottled mineral waters by means of their labelled physico-chemical and chemical composition. *Journal of Food Composition Analysis*, 15: 25 – 64
- U.S.E.P.A. (1989). *Quality criteria for water*. United States of Environment, Protugal Agency. E.P.A. – 440/9 – 76023, Washington D.C
- WHO (1990). Environmental Health Criteria 101, Methyl mercury. International programme on chemical safety, Geneva. 88p.

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Diversity of macroinfauna in different mangrove vegetation types in Kono Creek, Niger Delta**Zabbey, N.¹, Francis, A.¹, Hart, I.A.², Babatunde, B.B.², Ikpewe, I. E. and Nwipie, G.N.¹**¹Department of Fisheries, Faculty of Agriculture, University of Port Harcourt, Choba, PMB 5323, Rivers State, Nigeria.²Department of Animal and Environmental Biology, Faculty of Biological Sciences, University of Port Harcourt, Choba, PMB 5323, Rivers State, Nigeria.Correspondence: nenibarini.zabbey@uniport.edu.ng**Abstract**

Near pristine ecosystems are becoming scarce in the Niger Delta due to the cumulative impact of human activities. Sustained monitoring data are necessary to detect environmental changes in time and space, but such datasets on key ecosystems in the Niger Delta (e.g., on mangroves) are limited. Macrobenthos infaunas are essential biomonitoring tools because they are diverse, relatively abundant, well distributed and live long amongst other advantages. Some priority physicochemical parameters and the diversity of macroinfauna of tidal flats with varied status of vegetation (namely, nipa palm, red mangrove and deforested swamps) in Kono Creek were studied using standard procedures from October – December 2017. The spatial and monthly salinity, DO, conductivity, pH and TDS were similar, except temperature that differed inter-month ($p < 0.5$). The macrobenthic infauna were represented by seventeen species of eleven families. Species richness and diversity were higher in nipa palm, followed by native red mangrove than in the deforested swamp. It is plausible that long-term varied intensity of human interference is accountable for the pattern of diversity. This study confirms the presence of *Cyrenoida* sp. in the coastal environment of Nigeria. The densities of the fauna varied from 8 - 1125 m⁻². The high relative abundance of *Upogebia furcata*, which is very sensitive to organic pollution, highlights the near-pristine status of the Kono Creek. The implications of study for monitoring and management decisions of the ongoing Ogoniland cleanup and restoration project are discussed.

Keywords: Macrozoobenthos, Restoration, Mangrove Ecosystem, Integrity, Biodiversity.**Introduction**

The usefulness of collecting pre-disturbance biodiversity baseline data in the Niger Delta have been stressed by several authors (Kio and Ola 1985), but the task is far from being realized. This is much more for the mangrove biodiversity of the Niger Delta, Africa's largest expanse of mangroves (Spaliding *et al.*, 2010). However, the import of documenting pre-disturbance baseline data for change detection was recently illustrated using Bodo Creek macrozoobenthos pre- and post-spill datasets collected over seven years (Nwipie *et al.*, 2019). Mangroves in the Niger Delta are amongst the least studied but the worst impacted on the global scale. For example, a recent analysis of the impact of oil pollution on mangroves indicates that 27% of the global impact had been experienced in the Niger Delta (Duke, 2016). Nwobi *et al.* (2020) estimated that the invasive nipa palm (*Nypa fruticans*) spread at an alarming rate of 694% in the Niger Delta between 2010 and 2017. Other human activities that have major impact of the structure, diversity and dynamic productivity of mangroves in the Niger Delta include sand mining, channelization, fragmenting, plastic pollution, deliberate cutting for neighbourhood security and conservation for residential and industrial uses (UNEP, 2011; Zabbey *et al.*, 2021).

The history of nipa palm colonization in Nigeria and its magnitude in the Kono Creek have been documented (Zabbey and Tanee, 2016). The Kono Creek is one of the last near-pristine near-shore coastal ecosystems in the Niger Delta -at least from the standpoint of oil pollution. It has one of the last standing community-led mangrove reserves in the delta region. We surveyed infauna macroinvertebrates of three vegetation landscape in the Kono Creek, namely, native mangrove, nipa palm and deforested swamps to determine their varied community diversity. The dataset generated have essential monitoring implications for sustainable mangrove management and tracking changes in the environmental quality of mangroves in the region. The usefulness of macroinvertebrates in detecting changes in environmental conditions of hydrosystems is well documented (e.g. Gray and Elliot 2009).

Materials and Methods

Study Area

Kono Creek is a bypass of the lower reaches of the Imo River, which forms the eastern extreme of the Niger Delta, Nigeria (NEDECO, 1961). It is a mangrove-sheltered tidally influenced network. The creek true mangrove plants are the red mangroves (*Rhizophora racemosa*, *R. mangle*, *R. harisonii*), white mangrove (*Avicennia germinas*), black mangrove (*Laguncularia racemosa*) and the invasive nipa palm (*N. fruticans*) (Zabbey and Tanee, 2016). The other common marginal vegetation of the Kono Creek are date palm (*Phoenix reclinata*) and screw pine (*Pandanus candelabrum*).

Sampling Stations:

Station 1 (N04°35.153', E007°30.731'): a homogenous, luxuriant nipa palm forested swamp (Figure 1). The sediment was characterized by peaty clay -chikoko. Station (N04°34.480', E007°30.644') 2: sited in the Nwinua Mangrove Conservation Area protected for over three decades. Station 3 (N04°34.403', E007°30.656'): a deforested site with few stands of relatively 'small' planted red mangroves and sprouting/juvenile nipa palms.

Sampling and laboratory procedures:

Three replicate infauna samples were collected at low tide from randomly thrown 20cm x 20cm quadrant, sieved with 0.5mm screen and preserved with borax-buffered 5% formalin mixed with Rose Bengal stain for three months (October – December 2017). Some priority physico-chemical parameters of Interstitial water in the dug-out pits were measured *in-situ* following standard procedures (APHA, 1998). In the laboratory, the macrozoobenthos specimens analyzed as described in Hart and Zabbey (2005) using standard keys and monographs (Day 1967; Fauchald, 1977). Dr. John Taylor (British Museum of Natural History) identified the *Cyrenoida* specimens.

Data analysis

Variations in physico-chemical parameters between stations and between months were analysed as a completely randomised design (CRD) using the procedures of Statistical Analysis Systems (SAS 1989) and the mean separation done at the 5% probability level using the least significant difference (LSD). Taxonomic richness (Margalef index), diversity (Shannon– Wiener index) and evenness indices (Pilu's) and dominance (Simpson's) were estimated using PAST 3.0 software.

Results

Water physico-chemical characteristics

Tables 1 and 2 show spatial and temporal variations in some priority water physico-chemical parameters assessed. Though the values of the parameters were not uniform across the stations, there was no significant spatial variation (Table 1). Temporally, while pH, salinity, DO, conductivity and TDS were similar, only temperature values had significant ($p < 0.5$) different values (Table 2).

Table 1: Spatial Variations in Physiochemical Parameters of Kono (October – December 2017)

Parameters	STN 1	STN 2	STN 3	SD±
pH	5.32±0.63 ^a	6.40±0.26 ^a	5.17±0.20 ^a	0.85
Temperature (°C)	26.8±0.36 ^a	26.8±0.28 ^a	27.0±0.42 ^a	0.54
DO (mg/l)	5.33±0.73 ^a	6.30±0.20 ^a	6.08±0.24 ^a	0.82
Salinity	1.29±0.16 ^a	1.38±0.68 ^a	1.80±0.21 ^a	0.67
Conductivity (mS/cm)	3.22±0.40 ^a	4.01±0.52 ^a	3.64±0.43 ^a	0.76
TDS (ppt)	2.25±0.38 ^a	2.50±0.42 ^a	2.45±0.32 ^a	0.57

Means in the same row with the same superscript are not significantly different ($p > 0.05$)

Table 2: Temporal variations in physiochemical parameters of Kono (October – December 2014).

Parameters	October	November	December	SD±
pH	5.98±0.41 ^a	5.13±0.71 ^a	5.77±0.96 ^a	0.84
Temperature (°C)	26.6±0.13 ^a	27.5±0.15 ^b	26.5±0.12 ^a	0.54
DO (mg/l)	6.25±0.08 ^a	6.27±0.26 ^a	5.20±0.67 ^a	0.82
Salinity	1.06±0.54 ^a	1.68±0.16 ^a	1.73±0.37 ^a	0.67
Conductivity (mS/cm)	4.06±0.06 ^a	3.36±0.31 ^a	3.45±0.73 ^a	0.76
TDS (ppt)	2.66±0.25 ^a	2.24±0.24 ^a	2.30±0.52 ^a	0.57

^{a-b} Means in the same row with the same superscript are not significantly different (p>0.05)

Macrozoobenthos Community Structure

The macrobenthic infauna were represented by seventeen specific taxa of eleven families (Table 3). The bivalves, *Keletistes rhizoecus*, *Loripes aberrans* and *Cyrenoida sp.* widely distributed. *Upogebia deltaura* also had euryzonal distribution with relative high abundance in the nipa palm swamp. The pattern of Margalef species richness was Station 1>Station 3>Station 2 (Table 3).

Table 3: Macroinvertebrate composition, abundance, distribution and diversity in Kono Creek mangrove swamps

Taxa	STN 1	STN 2	STN 3
Naididae			
<i>Ophidonais serpentina</i>	58		
Capitellidae			
<i>Capitella cf. capitata</i>	3	1	
<i>Notomastus tenuis</i>	2		
Eunicidae			
<i>Marphysa sanguinea</i>	2		
Nereidae			
<i>Nereis diversicolor</i>	22		2
<i>Nereis virens</i>	2		
<i>Nereis pelagica</i>	2		2
<i>Perinereis cultrifera</i>		10	2
Nephtyidae			
<i>Nephtys hombergi</i>	1		1
Syllidae			
<i>Syllis prolifera</i>	4		
Diagenidae			
<i>Clibernarius cooki</i>	1		
Callianassidae			
<i>Upogebia furcata</i>	41	10	13
Hippidae			
<i>Pachygrapsus gracilis</i>	1	1	
Lucinidae			
<i>Keletistes rhizoecus</i>	13	4	2
<i>Loripes aberrans</i>	5	5	3
<i>Cyrenoida sp</i>	225	95	118
Tellinidae			
<i>Macoma innominata</i>	7		2

Total number of taxa	16	7	9
Total number of Individuals	388	126	145
Margalef	2.35	1.24	1.61
Shannon	1.47	0.93	0.79
Evenness	0.29	0.36	0.24
Simpson	0.63	0.42	0.32

The rank-abundance curve for all species in the three different stations are presented in Fig. 1.

Discussion

The distinct floristic variability of the Kono Creek swamps (native red mangrove, invasive nipa palm and screw pine) provides a unique landscape for studies of comparative alpha-diversity across the different floristic zones. Patterns of diversity can easily be analysed using the rank-abundance curve (Dunstan et al., 2012). Plotting the curve should be a first-choice for abundance datasets (Magurran, 1988). Generally, the steeper the curve, the less the taxa evenly distributed (Kindt and Coe, 2005). Initially, the presence *Cyrenoida* sp. in the coastal environment of Nigeria was doubted (Rudo von Cosel Per. Comm.), but this study confirms the presence of the bivalve.

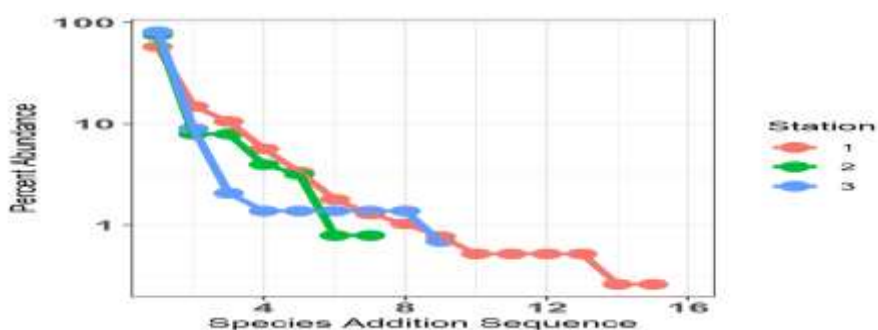


Figure 1. Species rank-abundance curve for the three stations

However, there is need for further morphological and molecular analyses of the *Cyrenoida* specimens to determine its lowest (i.e., species-level) taxonomy. The relatively high density of *U. furcata* recorded in this study indicates the near-pristine status of the Kono Creek, especially from the standpoint of organic load or oil pollution. *Upogebia* spp are considered indicator species, having been reported as grossly sensitive in organically enriched mangrove tidal flats in the Niger Delta (Chindah and Hart, 2000). These infauna datasets could influence management decisions of the ongoing Ogoniland cleanup and restoration project.

References

- Chindah, A. C. and Hart, A.I. (2000). Occurrence and distribution of epifauna and infauna community in Shallow mangrove wetland in the tropical West African region. *Afri. J. of Environ Stud.* 1: 76-83.
- Day, J.H., 1967. *A monograph on the polychaeta of Southern Africa*. British Museum of Natural History, London, UK. 878pp
- Duke, N.C. (2016). Oil spill impacts on mangroves: recommendations for operational planning and action based on a global review. *Marine Pollution Bulletin* 109:700–715, 2016.
- Dunstan, P.K., Bax, N.J., Foster, S.D., Williams, A., Althaus, F., 2012. Identifying hotspots for biodiversity management using rank abundance distributions: Identifying hotspots using rank abundance distributions. *Divers. Distrib.* 18, 22–32. <https://doi.org/10.1111/j.1472-.2011.00838.x>
- Fauchald, K., 1977. *The polychaete worms*. Definitions and keys to orders, families and genera. Natural History Museum. Los Angeles, USA, 188pp.
- Gray, J.S., and Elliot, M., 2009. *Ecology of marine sediments*. Oxford University Press, New York, USA.
- Kindt, R., Coe, R., 2005. *Tree diversity analysis: a manual and software for common statistical methods for ecological and biodiversity studies*. World Agroforestry Centre, Nairobi, Kenya.
- Kio, P. R. O., Ola-Adams, B. A. 1986. Utilization and development of wetlands. Paper delivered at the UNESCO MAB-5 Nigeria wetlands workshop, 3 – 6 May, 1986, PortHarcourt, Rivers State, Nigeria. Pp 68 – 74.
- Magurran, A. E. (1988). *Ecological diversity and its measurement*. Princeton, NJ: Princeton University Press.
- Netherlands Engineering Consultants, 1961. *The waters of the Niger Delta*. Reports on an investigation by NEDECO (Netherlands Engineering Consultants). 2nd Edition, The Hague.

- Nwipie, G. N., Hart, A. I., Zabbey, N., Sam, K., Prpich, G., & Kika, P. E., 2019. Recovery of infauna macrobenthic invertebrates in oil-polluted tropical soft-bottom tidal flats: 7 years post spill. *Environmental Science and Pollution Research*, 26(22), 22407-22420.
- Nwobi, C., Williams, M. and Mitchard, E. T. A. (2020). Rapid mangrove forest loss and nipa palm (*Nypa fruticans*) expansion in the Niger Delta, 2007-2017. *Remote Sensing* 12(14):2344.
- Spalding, M., Kainuma, M., and Collins, L., 2010. *World Atlas of Mangroves*. London, UK: Earthscan. UNEP, 2011. Environmental Assessment of Ogoniland. UNEP, Switzerland.
- Zabbey, N., Ekpenyong, I. G., Nwipie, G. N., Chris, I. D. and Sam, K (2021). Effects of Fragmented Mangroves on macrozoobenthos: A case study of mangrove clearance for Power-line Right-of-Way at Oproama Creek, Nigeria. *African Journal of Aquatic Science* <https://doi.org/10.2989/16085914.2020.1832437>
- Zabbey, N., and Tanee, F. B. G., 2016. Assessment of asymmetric mangrove restoration trials in Ogoniland, Niger Delta, Nigeria: lessons for future intervention. *Ecological Restoration* 34 (3): 245 – 257.

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Spatial Variations of Physico-Chemical Properties in Lokpanta Reservoir Ishiagu, Ebonyi State

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Abstract

Lokpanta Reservoir Ishiagu, Ebonyi State, used for fishing and domestic purposes is close to an active mining pit. Spatial variations of physico-chemical properties in Lokpanta Reservoir were evaluated for the impact of mining wastes in five purposely selected stations from April 2014 to March 2016. Physico-chemical parameters including alkalinity, hardness, sodium, calcium, iron, zinc, chloride, Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) were determined using standard methods. Data were analyzed using descriptive statistics, ANOVA and Principal Component Analysis (PCA) at $\alpha 0.05$. Mean values of iron (4.68 ± 0.86 mg/L), sodium (1638.34 ± 188.71 mg/L), calcium (1664.60 ± 397.68 mg/L), total hardness (53926.80 ± 7894.56 mg/L), chloride (6590.22 ± 852.11 mg/L), TDS (5739.55 ± 830.96 mg/L) and TSS (313.13 ± 36.86 mg/L) in the mining pit were significantly higher ($p < 0.05$) than values in other stations and were beyond WHO limits while levels of TSS were above WHO limit in all the stations. Principal component analysis (PCA) showed a high relationship between the mining pit and iron, sodium, TDS, total hardness as well as alkalinity. The mining pit was the most polluted station. Water quality was adversely affected by TSS in the reservoir, Nzohu River and mining pit. Thus, Lokpanta Reservoir, Nzohu River and the mining pit were probably polluted from inorganic sources. Therefore, Lokpanta Reservoir is not suitable for domestic use and could be a threat to aquatic biota.

Keywords: Aquatic biota, Water quality, Water pollution, Mining wastes, Lokpanta Reservoir

Introduction

The impoundment of water ways in form of reservoir are necessitated for municipal water supply, hydroelectric power supply, irrigation and fishing purposes (Taiwo *et al.*, 2018). The structural modifications in water flow from a lotic to lentic water system drastically change the ecosystem which will also affect the physico-chemical parameters of such water bodies (Gillespie *et al.*, 2015). Anthropogenic activities within and around the water ways further contribute to the variations in the different properties of the water (Okogwu and Ugwumba, 2013., Okerenta and Nnoka, 2017). Water bodies have long been used for indiscriminate discharge of untreated industrial effluents as well as domestic wastes. Agro-chemicals/allied products are washed down into closest water body. Reservoirs are major repository of man's wastes and they are more susceptible to receive and retain the by-products of the different human activities which lead to their pollution (Aiwerioghene and Ayoadé, 2016).

Lokpanta Reservoir Ishiagu, Ebonyi State is close to an active mining pit where mining wastes are continuously discharged. Previous works in neighboring mining sites in Ishiagu showed high elevations of metal loadings (Ezekwe *et al.*, 2013., Oyediran and Ugwumba, 2019). However, there is no documented report on the spatial variations of physico-chemical parameters in Lokpanta Reservoir, the mining pit and the connecting Nzohu River. The findings from the current work will be useful as an ecological management tool for sustaining the aquatic biota as well as a guide for locals within and around the reservoir who depend on the water body for domestic purposes and fishing.

Materials and methods

Lokpanta Reservoir is in Ishiagu, Ivo local government area of Ebonyi, State, Nigeria which lies between latitude $7^{\circ}29' 13.65''$ to $7^{\circ}29' 48.01''$ E and longitude $5^{\circ}58'25.02''$ and $5^{\circ}58'37.49''$ N with elevation of 86.3m above the sea level. The reservoir has a total estimated area of 97,000m².

Description of study area

Lokpanta Reservoir is in Ishiagu, Ivo local government area of Ebonyi, State, Nigeria. The sampling stations were divided into five stations.

Station 1: Inlet of the reservoir; Station 2: Middle of the reservoir; Station 3: Outlet of the reservoir; Station 4: Mining pit and Station 5: Nzohu River.

Sampling of Physico-chemical Parameters

Monthly sampling was done between April 2014 and March, 2016

Determination of Physico-chemical Parameters of surface water

Physico-chemical Parameters temperature, transparency, pH, Nitrate, phosphate, alkalinity, total hardness, chloride, dissolved oxygen, biological oxygen demand, total dissolved solid (TDS) total suspended solids (TSS) and metals concentrations were determined using method as described by APHA (2005).

Data Analysis

Data were analyzed using descriptive statistics, ANOVA and a multivariate method of Principal Component Analysis (PCA) was used to analyse the relationship between the physico-chemical parameters.

Result

The variations in levels of physico-chemical parameters are represented in table 1. There were significant differences ($p < 0.05$) in concentrations of TDS, chloride, total hardness, calcium, sodium, iron and zinc in the mining pit and between other stations. The mean concentrations of iron, total hardness, chloride and sodium were above world health organization's limits (WHO) in the mining pit and Nzohu River Station. The PCA ordination plot as shown in figure 1 associated transparency and water temperature with in inlet of the reservoir while pH was more evidenced in the middle and outlet of the reservoir and iron, sodium, calcium, TDS, TSS, total hardness, chloride, conductivity, alkalinity were connected with the mining pit while the Nzohu River Station was intermediate to levels the physico-chemical parameters and metals.

Table 1: Spatial variation of Physico-chemical Parameters of Lokpanta Reservoir

Parameters	Inlet of the Reservoir	Outlet of the Reservoir	Middle of the Reservoir	Mining pit	Nzohu River	WHO
Transp.(m)	0.29 ^b	0.23 ^b	0.11 ^a	0.06 ^a	0.10 ^a	-
Temp(oC)	28.46 ^a	27.47 ^a	27.65 ^a	26.41 ^a	27.26 ^a	25-30
pH	7.13 ^a	7.24 ^a	7.30 ^a	6.55 ^a	7.18 ^a	6.5-8.5
DO (mg/L)	4.70 ^a	4.88 ^a	4.72 ^a	4.46 ^a	6.30 ^a	>6
BOD(mg/L)	2.54 ^a	2.58 ^a	2.68 ^a	1.00 ^a	1.83 ^a	3
TDS(mg/L)	3.87 ^a	10.88 ^a	29.55 ^a	5739.55^d	2288.05 ^b	250-500
TSS(mg/L)	16.02 ^a	6.94 ^a	64.95 ^b	313.13 ^c	151.56 ^c	-
Cond(μ/cm)	0.03 ^a	0.01 ^a	0.03 ^a	11.37 ^c	1.54 ^b	250
Alkalinity(mg/L)	3.49 ^a	3.09 ^a	7.92 ^b	32.61 ^c	17.74 ^c	250
Nitrate(mg/L)	2.41 ^a	0.50 ^a	1.30 ^a	8.97 ^b	3.78 ^b	10
Phosphate(mg/L)	0.02 ^a	0.01 ^a	0.02 ^a	0.03 ^a	0.02 ^a	5.0
Sulphate(mg/L)	0.09 ^a	0.00 ^a	0.24 ^a	4.08 ^c	1.27 ^b	500
Chloride(mg/L)	44.62 ^a	21.08 ^a	42.87 ^a	6590.22^c	647.74 ^b	250
Hardness(mg/L)	10.48 ^a	8.58 ^a	19.14 ^a	53926.80^c	2549.77 ^b	150-500
Calcium(mg/L)	0.97 ^a	0.42 ^a	1.98 ^a	1664.60^c	171.21 ^b	-
Sodium(mg/L)	1.19 ^a	0.70 ^a	1.38 ^a	1638.34^c	217.19 ^b	200
Iron(mg/L)	0.006 ^a	0.001 ^a	0.05 ^b	4.68^c	0.92 ^{ab}	0.3
Zinc(mg/L)	ND	ND	0.002 ^a	0.022^b	0.007 ^a	3

N.B: Values with the different superscripts along the same row are significantly different at $p < 0.05$. Transp =Transparency, Temp=Water Temperature, DO=Dissolve Oxygen, BOD = Biochemical Oxygen Demand, TDS=Total Dissolved Solids, TSS=Total suspended solid, Cond=Conductivity, Alka=Alkalinity, Nit= Nitrate, Pho=Phosphahate, Sul=Sulphate, Cl=chloride, Hard=Hardness, Ca= Calcium, S= Sodium, Fe= Iron, Zn= Zinc Station 1: Entrance of the reservoir, Station 2: Middle of the reservoir, Station 3: Outlet of the reservoir, Station 4: Mining pit, Station 5: Nzohu River

Discussion

The low pH recorded in the mining pit may be connected with acid mine drainage (AMD) (Ezekwe *et al.*, 2013). Leachate from mining explosives with a component of acid used during the mining activities could also be attributed to the reduced pH level in the mining pit ; this possibly resulted in the increase of sulphate levels which could have

reacted with water to form acid in the mining pit as reported by Fernandes (2015). The increased level of nitrate especially in the mining pit and Nzohu River Station may possibly be attributed to the nitrogen component of the mining explosives which are oxidized to nitrate as reported by Karlsson and Kauppila (2015) in a quarry located in Varpaisjärvi, northern Savonia, Finland. It is evinced that the materials mined from the pit are composed of iron, zinc, sodium and calcium because of their high loadings which are above the permissible standards of WHO. The mining pit is thus mostly polluted and the wastes were transported to other stations. Although, previous reports of Okerenta and Nnoka (2017) and Asiegbu *et al.* (2021) in the neighboring mining sites in Ishiagu only documented high concentrations of metals.

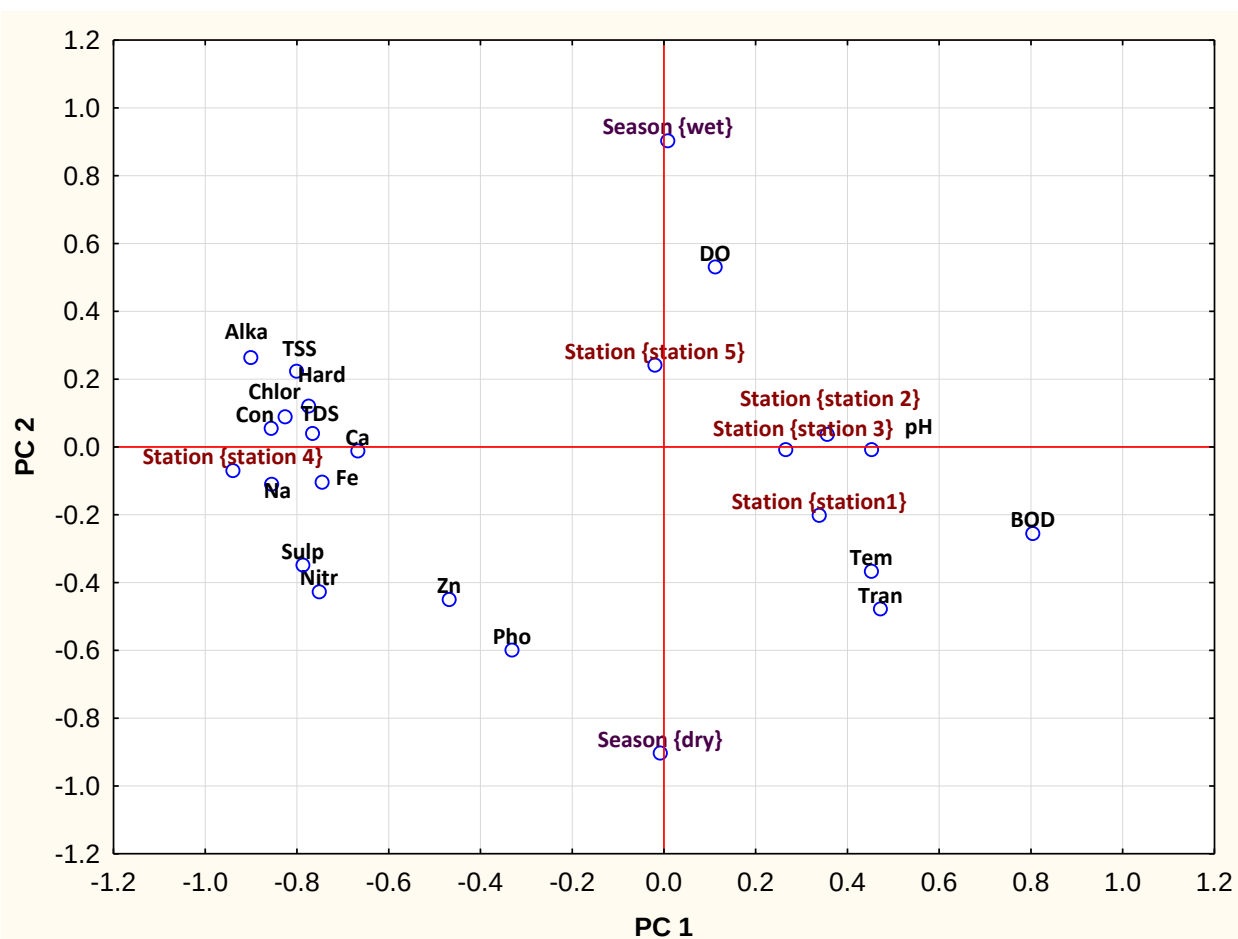


Figure 1: Principal Component Analysis (PCA) ordination-plot of physico-chemical parameters and stations

inLokpanta Reservoir.

Key: Station 1= Inlet of the reservoir, Station 2= Middle of the reservoir, Station 3= outlet of the reservoir, station 4= mining pit, station 5= Nzohu River, Tem=Water Temperature, pH=pH, DO=Dissolve Oxygen, BOD = Biochemical Oxygen Demand, TDS=Total Dissolved Solids, TSS=Total suspended solid, Con=Conductivity, Alka=Alkalinity, Nitr= Nitrate, Pho=Phosphate, Sulp= Sulphate, Chlor=Chloride, Hard= Total Hardness, Ca= Calcium, Na= Sodium, Fe=Iron, Zn=Zinc, Tran =Transparency.

Conclusion

The high levels of metals along with TDS, chloride, calcium, sodium and total hardness in Nzohu River Station was occasioned by its proximity to discharge point of wastes from the mining pit. The pollution in Lokpanta Reservoir is inorganic. It is important to understudy the water quality in downstream of Nzohu River where the mining discharge flows to access the impacts of the mining discharge. In the same vein, locals within and around Lokpanta Reservoir should be discouraged from consuming the fish as well as be discouraged from using the water for domestic purposes while it is recommended that sustainable methods should be adopted in the mining activities in order to conserve the aquatic biota and the humans who depend on the reservoir for daily usage.

References

- Aiwerioghene, A. O. and Ayoade, A. A. (2016). Evaluation of some Physico-chemical parameters and benthic macroinvertebrates of Ikere Gorge Reservoir in Oyo State, Nigeria. *Journal of Applied Science and Environmental Management* 20.4: 1097-1103.
- American Public Health Association (APHA) (2005). Standard Methods for the Examination of Water & Wastewater Analysis, 21st Edition, American Water Works Association/Water Environment Federation, Washington D.C.
- Asiegbu, V. O., Oyediran, A.G. and Ezekwe,, I. C. (2021) conservation status of fish fauna in Ivo River Basin Southeastern Nigeria. *Acta Scientific Microbiology Journal* 4(7): 3-7
- Ezekwe, C. I., Ezekwe, S. A and Chima, N. G. 2013. Metal Loadings and alkaline mine drainage from active and abandoned mines in the Ivo River Basin Area of Southeastern Nigeria. *Mine Water Environment* 32: 97–107.
- Fernandes, N. V. 2015. Impact of iron ore mining: comparison of physicochemical parameters and heavy metals in upstream and downstream sites of a river. *International Journal of Scientific Research* 4.7: 254-257.
- Gillespie, B. R., Brown, L. E. and Kay, P. (2015) Effects of impoundment on macroinvertebrate community assemblages in upland streams. *River Research and Applications* 31: 953–963
- Karlsson, T. and Kauppila, T. 2015. Release of explosives originated nitrogen from the waste rocks of a dimension stone quarry. 10TH International Conference on Acid rock drainage and IMWA Annual conference. pp1-8.
- Okerenta, B. M. O and Nnoka, C. U. O 2017. Seasonal variations in physico-chemical and bacteriological parameters of Ulas River, Okija, Anambra State. *Asian Journal of Environment and Ecology* 2.2: 1-9.
- Okogwu I. O. and Ugwumba, A. O. 2013. Seasonal dynamics of two tropical lakes of varying size and human impacts in southeast Nigeria *Revista de Biología Tropical* 61.4: 1827-1840.
- Olanrewaju A. N, Ajani E. K., Kareem, O. K and Orisasona, O. 2017. Relationship between Physico-Chemical Parameters and Reproductive Indices of *Parachanna obscura* (Gunther 1861) in Eleyele Reservoir, Ibadan, Nigeria. *EurExp Biol.* 7 (6):36-45
- Oyediran, A. G. and Ugwumba A. A. A. (2019) Impact of mining discharge on spatial abundance and distribution of benthic macroinvertebrates in Lokpanta Reservoir, Ishiagu, Ebonyi State, Nigeria. In Ude, E.F.(Ed), Proceeding of the 34th Annual Conference of Fisheries Society of Nigeria (FISON) (pp 390-392). Abakaliki, Nigeria: FISON.
- Taiwo, Y. F., Adedeji, A. A. and Adesakin, T. A. 2018. The Ecological Balance of the Fish Community in an Aging Reservoir. *Natural Resources* 9: 327-335

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Length–Weight Relationship and Condition Factor of Fresh Water Turtle (*Pelusios castaenus* and *P. niger*) in South-West Nigeria

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Abstract

Seasonal study in ecology is an important approach in studying habitat biodiversity. Determination of length weight relationship of fresh water turtle *P. castaenus* and *P. niger* from wild habitat will reveal the ecological differences that impact on the life stages of turtle as a result of change in season. This study was conducted in Sagamu Local Government Area of Ogun State, South Western Nigeria. Collection of turtle was done by hand picking of hatchlings/juveniles and by using two-way valve cane trap for adult entrapment, during the early rainy season 2020. The objective of the study was to investigate seasonal changes in morphometric of fresh water turtle. Standard techniques of length-weight and length weight relationship were used to analyze data obtained with graphical presentation. Six (n=6) turtle carapace length range 3.80-23.70cm and weight 9.96-1225.00g. Length weight relationship indicated allometric growth (TW:CL; TW:PL; TW:CW; TW:PW) (2.78; r^2 0.99); (2.78; r^2 0.99) (2.46; r^2 0.98) (2.64; r^2 0.98) with negative intercepts and mean condition factor (12.65) denoting habitat stability for growth and reproduction.

Keywords: African sideneck Turtle, allometry, breeding season, hatchling.

Introduction

The response of species to biological changes and habitat response to morphological characteristics with respect to growth pattern is studied under length-weight relationship (Clarito, 2021). Turtles living in different habitat differ in morphology, body sizes and stages of life development (Marn *et al.*, 2015). *Pelusios spp.* classification has been well researched with distinct morphological features that differentiates *P. subniger* (Shi *et al.*, 2013); *P. castaneus* (Bour *et al.*, 2016) and *P. niger* (Luiselli *et al.*, 2018) respectively. There is need to provide more relevant information to aid the reproduction and husbandry requirement of herpetology especially the commercially valued species. This will give more insight to study the hitherto poorly described, and rarely captive kept breeds which will provide relevant data that will be accessible for capture breeders (Lagner *et al.*, 2020). Study on turtle is low due to seasonal and yearly data collection which has made researchers to abandon long term experiments to determine the biology of these species (Tsaliagos, 2002) and is a long term research that have spanned over two decades in Nigeria (Akani *et al.*, 1999; Bour *et al.*, 2016; Luiselli *et al.*, 2018).

Dimensional measurement of all morphological traits and life stages in the natural habitat is impracticable and impossible as shell length is mostly reported for turtles while it is the relationship between shell, other parameters and how these differs with areas as well with life stages that is most important (Marn *et al.*, 2015). In accordance with Rawski and Józefiak (2014) there is dearth of information about correlation of length–weight relationship (LWR) of fresh water turtle in Nigeria. The study of *P. castaenus* and *P. niger* with respect to LWR in South Western Nigeria is hereby considered.

Materials and methods

Description of the study area

The study site has a tropical climate pattern with distinct season (Sule *et al.*, 2020a) and geographical coordinates achieved with the use of GPS Waypoints. The study site falls within 6.822000 latitude and 3.640308 longitude, altitude MSL-4.08m, bearing 352.84, accuracy 5.50m and UTM zone 31N.

Collection of fish samples

Turtle samples (n=6) were collected from the study area during the early rainy season from 10-29 May 2020 using a two-way valve local cane fish trap. Turtle Samples could not be taken to the laboratory of Department of Fisheries Management College of Agricultural Sciences, Olabisi Onabanjo University but were further investigated on site due to Covid -19 pandemic movement restriction.

Laboratory techniques

The shell length and width (carapace and plastron) was measured using a technical drawing board and T square meter rule as measurement board in taking length measurements (cm). An electronic weighing balance was used to take the weight (g). Data generated was subjected to length – weight relationship analysis as described by Sule *et al.*, (2020a) using the methods of Pauly (1984): $W = aL^b$ for length weight factors and using linear regression analysis for logarithmic transformation values of length and weight of constant values of “a” and “b”: $\log W = \log a + b \log L$. While Fulton’s Condition Factor (K) = $100W / L^3$ (Ikomi and Odun, 1998).

Statistical analysis

Length-weight relationship and condition factor data were analyzed statistically with Microsoft Excel package while the statistical description and association level of length–weight was subjected to correlation and regression analysis.

Results

Length-weight measurement

Ranges and mean values of length and weight of *Pelusios spp* (n=6) from early season 1 study are presented in Table 1. Weight ranged indicated that hatchlings were among the samples collected with an equal ratio compared to the adult 50:50; 33% male; 67% female with 33%:67% sex ratio for the hatchlings respectively.

Table 1: Ranges and mean values of length and weight of *Pelusios spp* from early season 1 study

Parameters	Range, $\pm$ SE
Carapace Length Range (cm)	3.80 – 23.70
Mean Carapace Length (cm)	12.55 $\pm$ 3.84
Total Weight Range (g)	6.96 – 1225.00
Mean Total Weight (g)	480.37 $\pm$ 218.88
Plastron Length Range (cm)	3.50 - 20.00
Mean Plastron Length (cm)	11.03 $\pm$ 3.37
Carapace Width Range (cm)	3.00 – 19.90
Mean Carapace Width (cm)	11.05 $\pm$ 3.61
Plastron Width Range (cm)	2.00 - 14.00
Mean Plastron Width (cm)	8.25 $\pm$ 2.55
K factor	9.20 - 20.49
Mean K factor	12.65 $\pm$ 1.65

Length-weight relationship

Table 2 showed the values of the regression constant of the length-weight relationship of *Pelusios spp*. The values of “a” were significantly lower ($p < 0.05$) than 3 in Total Weight:Carapace Length (TW:CL); Total Weight:Plastron Length (TW:PL); Total Weight:Carapace Width (TW:CW); Total Weight:Plastron Width (TW:PW). The regression summary (r^2) and correlation coefficient (r) were positively correlated and not significantly different

Table 2: Length and weight relationship of *Pelusios spp* from early season 1 study.

Logarithm	Regression Coefficient		Regression Summary r^2	Correlation Coefficient r
	b	SE		
TW:CL	2.78 $\pm$ 0.11	-0.70 $\pm$ 0.11	0.99	0.997
TW:PL	2.78 $\pm$ 0.15	-0.54 $\pm$ 0.14	0.99	0.995
TW:CW	2.46 $\pm$ 0.16	-0.18 $\pm$ 0.16	0.98	0.991
TW:PW	2.64 $\pm$ 0.18	-0.06 $\pm$ 0.14	0.98	0.991

TW:CL= total weight:carapace length; TW:PL= total weight:plastron length; TW:CW= total weight:carapace width; TW:PW= total weight:plastron width.

Discussions

Experimental site was within the area reported for the occurrence of freshwater turtles by Bour *et al.*, (2016); Luiselli *et al.*, (2018) with distribution up to the Sudan savanna region (Umar *et al.*, 2020). The use of small sample size was similar to the report of Rawski and Józefiak (2014) $n=5$ in *P. castaneus*. All ranges and means were lower, with the upper limit ranges and means within the values reported for the dry season study by Sule *et al.*, (2020a). The lower ranges revealed that hatchlings/juvenile turtle was among the samples collected.

The K factor in this study was significantly higher than values of 8.27; 10.04 in Sule *et al.*, (2020a). Bello-Olusoji *et al.*, (2009) reported higher K factor values of 32.19 for freshwater crab caught from the wild. This lends credence to the fact of habitat improvement due to inflow of fresh water from sub streams in the area. Rawski and Józefiak (2014) reported that wild African side neck turtle population should be used in studying condition factor, carapace length and weight relationship of the species.

Parameters of TW:CL; TW:PL; TW:CW in Sule *et al.*, (2020a) were lower in “b” than in this study. However, the intercept “a” of this study showed negative values as against TW:PL; TW:CW of positive values in Sule *et al.*, (2020a). Similar negative intercept was observed for *C. gariepinus* collected from the wild (Sule *et al.*, 2020b) indicating non-proportionality in body length to weight of the fresh water turtle. The “ r^2 ” and “r” values in this study showed higher positive correlation over Sule *et al.*, (2020b). Relationship between TW:CL in line with Rawski and Józefiak (2014) of positively correlated “ r^2 ” (0.98). Mean weight increase in samples caught during late season one in this study support the report of Tsaliagos (2002). Brophy (2006) used CL as independent variable for allometric variation while using only adults and larger sub-adults. Allometric relationship of *M. macrocephala* CW and “ r^2 ” (2.43; 0.98) in Brophy (2006) was similar to result obtained in this study. Also, the relationship can be compared with the West Africa freshwater Crab *S. africanus* in which all wild samples showed allometric response (Bello-Olusoji *et al.*, 2009).

On using external morphological characters reported by Bour *et al.*, (2016) and Luiselli *et al.*, (2018), it was observed that 16.67% ($n=1$) was *P. niger* which was in the hatchling/juvenile stage and the remaining 83.33% ($n=5$) were *P. castaneus* and this was in line with the co-existence in the same habitat of the two species already documented by Akani *et al.*, (1999); Luiselli *et al.*, (2000). Identifying hatchlings/juveniles in this study supported the findings of Segniagbeto *et al.*, (2015) in population regeneration which can lead to increase in population biodiversity of the species. Salmon and Scholl (2014) reported that threat to turtle has been noticed on hatchlings in the marine environment by dolphin fish *Coryphaena hippurus* as a result of reduced initial allometric growth in the wild. Temperature variation from seasonal changes was reported to affect growth of juvenile turtle (Tsaliagos, 2002). Total hatchlings/juvenile was 50% and more than 30% reported for *P. subrufa*, while 50% of samples fell within the CL of Segniagbeto *et al.*, (2015). Sex and life stages of 33% for male, female and hatchlings/juveniles noticed by Rawski and Józefiak (2014) this was as a result of inability to identify sexes of the hatchlings/juveniles and contrary to our observation in this study.

Conservation measures that can best be used in achieving stable population are statutory regulation of commerce, head starting and stocking hatchlings in areas known to be depleted in stocks (Dodd 1988). Luiselli *et al.*, (2018) also pointed out conservational study of the species from egg to maturity. The best conservation method in this study area will be to raise the awareness of the citizenry to the importance of protecting the biodiversity of the area and not trading collected turtle for either consumption or ethno-medicine.

Conclusion

The length and weight showed allometric growth in which corresponding weight led to length increment while the condition factor revealed a stable habitat for the growth and reproduction of the *Pelusios species* found in the study area.

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References

Akani, G.C., Luiselli, L., and Politano, E. (1999). Ecological and conservation considerations on the reptile fauna of the eastern Niger Delta (Nigeria). *Herpetozoa* 11:141–153.

- Bello Olusoji, O.A., Anifowose, O.J. and Sodamola, M. Y. (2009). Length-weight relationships, condition factor and fecundity of the West Africa freshwater crab, *Sudanonautes africanus* (Milne-Edwards 1883), in Western Nigeria. *West African Journal of Applied Ecology*, 16: 65-74
- Bour, R., Luiselli, L., Petrozzi, F., Segniagbeto, G.H., and Chirio, L. (2016). *Pelusios castaneus* (Schweigger 1812) – West African mud turtle, swamp terrapin. In: Rhodin, A.G.J., Pritchard, P.C.H., van Dijk, P.P., Saumure, R.A., Buhlmann, K.A., Iverson, J.B., and Mittermeier, R.A. (Eds.). Conservation biology of freshwater turtles and tortoises: A compilation project of the IUCN/SSC tortoise and freshwater turtle specialist group. *Chelonian Research Monographs* 5(9):095.1–11.
- Brophy, T. R. (2006). Allometry and sexual dimorphism in the snail-eating turtle *Malayemys macrocephala* from the Chao Phraya River Basin of Central Thailand. *Chelonian Conservation and Biology*, 5(1): 159–165.
- Clarito, Q. Y (2021). Length-weight relationship and relative condition factor of Yellowstripe scad, *Selaroides leptolepis* (Cuvier, 1833) in the Visayan Sea, Philippines. *Aceh Journal of Animal Science* (2021) 6 (3): 74-78
- Dodd, C. K, Jr. (1988). Synopsis of the biological data on the loggerhead sea turtle *Caretta caretta* (Linnaeus 1758). *U.S. Fish Wildlife Service, Biological Report* 88(14). 110 pp.
- Ikomi, R.B. and Odun, O. (1998). Studies on aspects of the ecology of the catfish *Chrysichthys auratus* Geoffrey St, Hilaire (*Osteichytes Bagridae*) in the River Benin (Niger-Delta) Nigeria. *Fish Res.*, 26: 187-198.
- Langner, C., Pfau, B., Bakowskie, R., Arranz, C and Kwet, A. (2020). Evaluation of the captive breeding potential of selected reptile taxa included in appendices I and II at CITES CoP17. *German Society of Herpetology and Herpetculture*. 230 pp
- Luiselli, L., Bour, R., Petrozzi, F., Akani, G.C., and Segniagbeto, G.H. (2018). *Pelusios niger* (Duméril and Bibron (1835) – West African black mud turtle. In: Rhodin, A.G.J., Iverson, J.B., van Dijk, P.P., Stanford, C.B., Goode, E.V., Buhlmann, K.A., Pritchard, P.C.H., and Mittermeier, R.A. (Eds.). Conservation biology of freshwater turtles and tortoises: A compilation project of the IUCN/SSC tortoise and freshwater turtle specialist group. *Chelonian Research Monographs* 5(12):105.1–8.
- Luiselli, L., Politano, E., and Angelici, F.M. (2000). Ecological correlates of the distribution of terrestrial and freshwater chelonians in the Niger Delta, Nigeria: a biodiversity assessment with conservation implications. *Revue d'Ecologie (Terre et Vie)* 55:3–23
- Marn N, Klanjscek T, Stokes L, Jusup M. (2015). Size scaling in Western North Atlantic loggerhead turtles permits extrapolation between regions, but not life stages. *PLoS ONE* 10(12):e0143747.
- Pauly, D. (1984). Fish population dynamics in tropical waters: A manual for use with programmable calculators. *ICLARM Studies and Reviews* 8. 325p..
- Rawski, M and Józefiak, D. (2014). Body condition scoring and obesity in captive African side-neck turtles (*Pelomedusidae*). *Ann. Anim. Sci.*, 14(3): 573–584.
- Salmon, M and Scholl, J. (2014). Allometric growth in juvenile marine turtles: possible role as an antipredator adaptation. *Zoology*
- Segniagbeto, G. H., Afiademagno, K., Akani, G.C., Petrozzi, F and Luiselli, L. (2015). Sex ratio, size structure and morphometrics of turtle populations from Togo, West Africa (Testudines: Testudinidae, Pelomedusidae) *Herpetozoa* 28 (1/2): 29 – 38.
- Shi, H.T *et al.*, (2013). The identification manual for the conservation of turtles in China. Encyclopaedia of China 5p Publishing House. 18.
- Sule, S.O., Mohammed, R and Sotolu, A.O (2020a). Length–weight relationship and condition factor of fresh water turtle (*Pelusios sp.*) late season 1 study. 35th Annual Conference, Fisheries Society of Nigeria, (Niger 2020) 8th-11th November, Federal University of Technology, Minna. Niger State.
- Sule S.O., Oyetunji O.T, Durojaiye A.F., Tijani H.A., Fatokun A.S and Owodeinde, F.G. (2020b) Length–weight relationship, condition factor and fecundity of *Clarias gariepinus* (Burchell, 1822) from Epe Lagoon, Lagos State, Nigeria. *FUTO Journal Series (FUTOJNLS)* 6 (1): 17-24.
- Tsaliagos, R.N. 2002. Examining indeterminate growth in fresh water turtle. M.Sc. thesis Graduate Faculty of The University of Georgia, Athens, Georgia. 67pp.
- Umar, R., Bamaïyi, C., Mudi, Z. R., Usman, B. I. and Gadzama, I. M. K (2020). Aspects of breeding ecology of freshwater turtle (*Pelusios niger*) in the wild in Zaria, Kaduna State Nigeria. *FUW Trends in Science & Technology Journal*. 5 (1): 277 – 279.

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Length-weight relationship and condition factor of *Labeo coubie* in Upper Benue RiverAjijola, K.O.*¹ and Ugwumba, A.A.A.²¹Department of Fisheries, Modibbo Adama University, Yola Tel. 0706 344 9912² Department of Zoology, University of Ibadan, Ibadan**Abstract**

The length-weight relationship and condition factor of *Labeo coubie* in the Upper Benue River were investigated. Fish specimens were collected from the sampling station at Jimeta, Yola, Adamawa State, monthly from September, 2017 to February, 2019. Morphometric measurements, including standard length, body weight were recorded for a total of 849 specimens. Regression analysis of the length-weight relationship produced positive allometric growth coefficient, the values of regression coefficient (b) in males, females and combined sexes were 4.0281, 3.5246 and 3.3499 respectively. Condition factor obtained ranged from 2.35 - 3.38 (mean = 2.54 ± 0.22), 2.36 - 2.78 (mean = 2.52 ± 0.11) and 2.36 - 3.00 (mean = 2.53 ± 0.14) for males, females and combined sexes respectively. Fish condition factor, (2.39 – 3.38) was generally not significantly different ($p > 0.05$) between the seasons, except for December, 2017 ($k = 2.96$), during the dry season. The mean values of condition factor obtained 2.54, 2.52 and 2.53 showed that *L. coubie* was in a good state of wellbeing in the habitat during the period of study. These results confirm the suitability of Upper River Benue at Jimeta, Yola, Nigeria, for *Labeo coubie*.

Keywords: Positive allometry, growth pattern, stock assessment, maturity, energy allocation

Introduction

Studies on length-weight relationship and condition factor are a prerequisite to understanding natural populations of fish species, which is needed for proper conservation and exploitation (Osho and Usman, 2019). A knowledge of the growth pattern and condition of wellbeing of a fish goes a long way into easing the crucial work on its stock assessment and creates an entry point into study of the various aspects of its biology *Labeo coubie* is important species inhabiting tropical freshwaters rivers in Senegal, Gambia, Ivory coast, Liberia, Zaire and Gabon (Ayotunde *et al.*, 2007; Olufeagba *et al.*, 2016). In Nigeria, *L. coubie* inhabits freshwater rivers, such as Agbokim Waterfalls in Cross river state (Ikpi *et al.*, 2012) and Benue river (Olufeagba *et al.*, 2016). Till date, relatively little information is available on the fisheries of the African carp. More importantly, more research is necessary on stock assessment, biology, ecology, habitat status, threats, monitoring and potential conservation measures (Azeroual *et al.*, 2010). The aim of this paper is to analyze the length-weight relationship and determine the condition factor of *L. coubie* in Upper Benue river at Jimeta, Adamawa State, Nigeria.

Materials and methods

The study area (Figure 1) is located in a part of the Upper Benue River, at Jimeta, Girei Local Government Area of Adamawa State. Two sampling stations were selected on River Benue, located within $9^{\circ} 16' \text{ N} - 9^{\circ} 19' \text{ N}$ and $12^{\circ} 26' \text{ E} - 12^{\circ} 29' \text{ E}$, which serve as the fish landing sites for fishermen fishing in the study area (Figure 1). The stations are at coordinates $9^{\circ} 17.5'$ and $12^{\circ} 27.8\text{E}$.

Fish specimens were collected from the landing sites at the River Benue, located at Girei Local Government Area of Adamawa state and samples were taken from September, 2017 to February, 2019. Fish were caught using cast nets, lift nets, dip nets and traps. A total of 849 specimens were sampled for this study. They were transported to the laboratory using plastic tanks with ice packs. Morphometric measurements of fish were taken in the dry laboratory of the Fisheries Department of Modibbo Adama University of Technology (MAUTECH). The standard length of specimens was taken using measuring board and recorded to the nearest 0.1g. Total weight was taken using digital weighing machine model KERRO BL 5002. Length-weight relationship of fish was estimated from the equation:

$W = aL^b$ (Pauly, 1984) The relationship was transformed into a linear form:

$Y = a + bx$, $\log W = a + b \log L$, Where $Y = \log W$; $x = \log L$; W = weight of fish (in grams); L = standard length of fish (in cm); a = regression constant; b = allometric coefficient

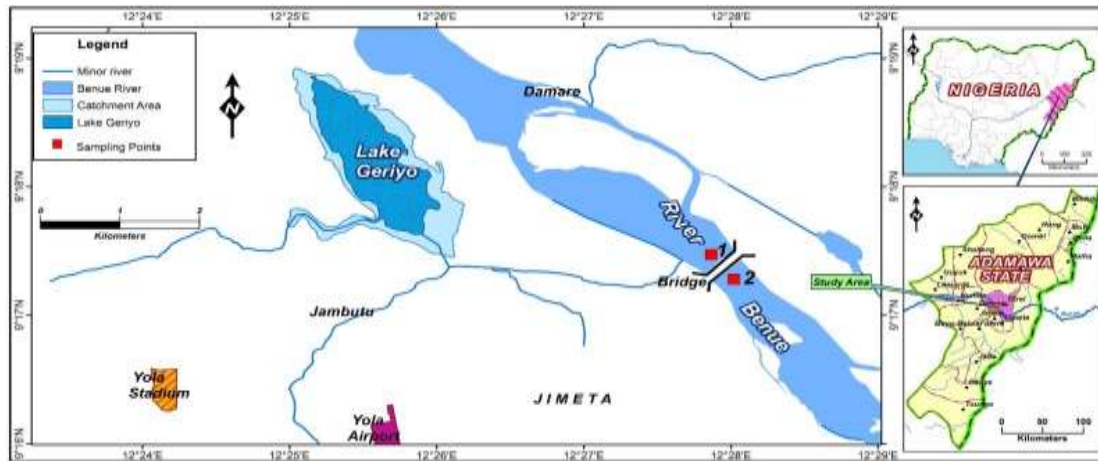


Figure 1. Map of Upper River Benue showing sampling stations

Fulton's condition factor (K) was calculated monthly using the formula described by Bagenal and Tesch (1978) as follows:

$$K = 100W/L^3$$

Results

Graphical representations of the regression equations of the length-weight relationship of male, female and combined sexes of *L. coubie* are presented in figure 2.

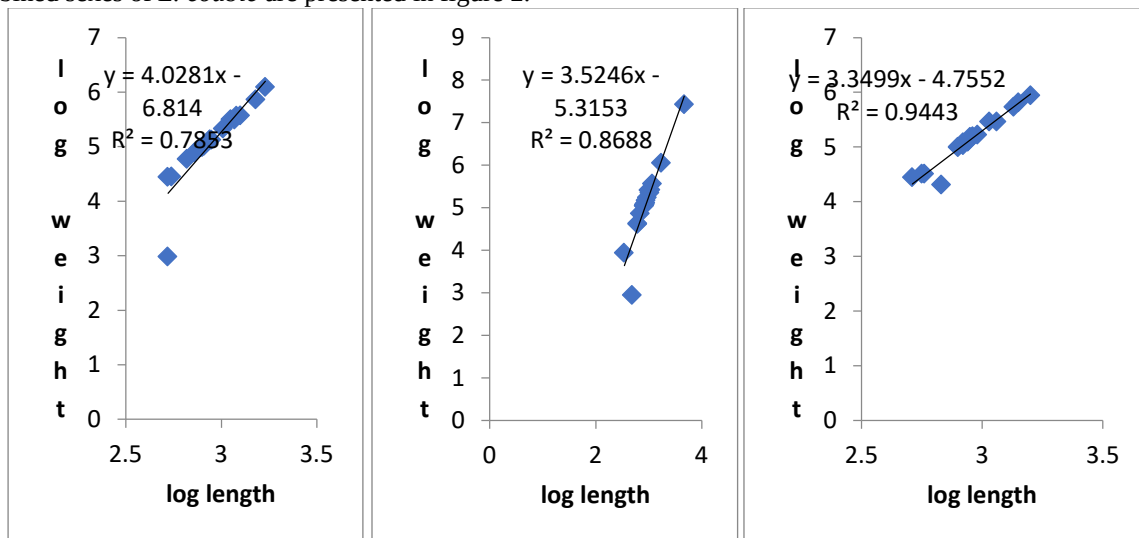


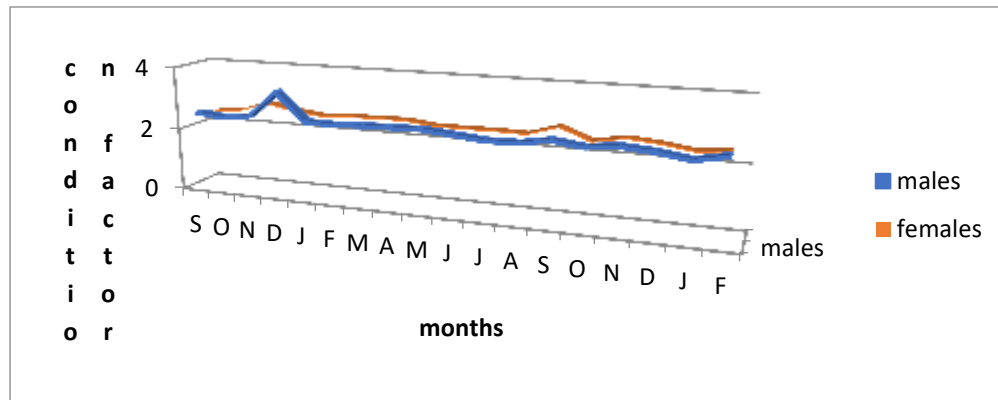
Figure 2: Length-Weight Relationship Curves Of *L. coubie*

From the regression equation, transformed into linear form – $Y = bx + a$, regression constant 'a' for fish are -6.814, -5.3153 and -4.7552 for males, females and combined sexes respectively. Allometric coefficient 'b' values were 4.0281, 3.5246 and 3.3499 for males, females and combined sexes respectively. All the three values are greater than 3, hence fish showed positive allometric growth. High correlation values of $r^2 = 0.89, 0.93$ and 0.97 for mean values of standard lengths and weights of *L. coubie*, were recorded. The equations $Y = 4.0281x - 6.814$ and $Y = 3.5246x - 5.3152$ were used to estimate the weight of a fish of known length, for males and females respectively.

Condition factor was generally not significantly different, $p > 0.05$, between the sexes of *L. coubie* in the present study. The only month in which significant difference ($p < 0.05$) was observed was in December, 2017.

Table 1: Length-Weight Equation Characteristics and Condition Factor, K of *L. Coubie* in Upper Benue River

Sex	L-W equation	b value	Correlation (r^2)	Mean condition factor, K	P value
Male	$Y = 4.0281x - 6.814$	4.0281	0.89	2.54 ± 0.22	0.11
Female	$Y = 3.5246x - 5.3153$	3.5246	0.93	2.52 ± 0.11	
Combined sex	$Y = 3.3499x - 4.7552$	3.3499	0.97	2.53 ± 0.14	

**Figure 3: Condition Factor of Male and Female *L. coubie* in Upper Benue River**

Discussion

Length-weight relationship of *L. coubie* in the present study has 'b' values > 3 , which indicates positive allometry. This shows a strong positive association between length and weight of the fish. Thus, the fish grows wider with slight increase in length. Allometric growth is observed when the dimensional growth rates of fish with respect to length and width or size are not the same (Bolarinwa, 2017). The results observed in this study are comparable with those of previous researches: Olufeagba *et al.* (2016) discovered 'b' values of around 3, indicative of isometric growth, for male *L. coubie* and 2.63, indicating negative allometric growth pattern, for females in Lower Benue river. Same study also gave values with insignificant positive deviation from the allometric coefficient 'b' of 3.07 and 3.04 for *Labeo senegalensis*, males and females respectively. In another research, Ayoade (2011) reported a negative allometric growth pattern in the smallest studied size group ('b' < 3) and isometric pattern ('b' = 3) for other groups of *Labeo ogunensis* in Asejire lake. *Labeo parvus* in Queme river was reported (Laleye, 2006) to exhibit positive allometric growth ('b' > 3), while Konan *et al.* (2007) reported an isometric growth pattern for *L. coubie* in coastal rivers. The differences in the slope of length-weight regression analysis 'b' and in essence, the growth pattern of fish can be related to factors, such as size and age of fish, species, water condition or parameters, stage of maturity (Weatherly and Gill, 1987), food availability (Mommsen, 1998) and sex of fish.

The mean values of condition factor, K recorded for *L. coubie* in Upper Benue river in the present study were greater than 1: 2.54 ± 0.22 and 2.52 ± 0.11 , for males and females respectively. This implies that the species is in satisfactory condition of wellbeing, necessary to support moderate somatic growth and possibly, reproduction. These results are in accordance with those of Olufeagba *et al.* (2016), who also observed mean K values ranging from 2.12 to 2.45, for *L. coubie* and *L. senegalensis* in Lower Benue river. Ayoade (2011) reported mean values of 1.1 for *L. ogunensis*, Adadu *et al.* (2014) observed mean value of 1.84 for *L. coubie* in Lower Benue river, while Ikape and Solomon (2018) reported 0.73. Lower values of K, less than 1, were also reported by Ikpi *et al.* (2012) for *L. coubie* in Agbokim Waterfalls. Differences in values of condition factor of fish can be linked to factors, such as food availability (Mommsen, 1998), space, sex and physiological condition of fish and season. Thus, in most gravid fish species, priority is given to energy allocated to metabolism and reproduction (Barron *et al.*, 2012; Rodrigues *et al.*, 2013). More energy is spent on metabolism, gonad maturation and production of eggs and sperm during the spawning season, which usually coincides with the rainy season. This causes a reduction in the condition factor of the spawning fish.

References

- Adadu, M.O., Omeji, S. And Oyeniji, M.E. (2014). Food, feeding habits and condition factor of African Carp, (*Labeo coubie*) in Lower River Benue. *Journal of Global Biosciences* 3.6: 890-894
- Ayoade, A.A.(2011). Length-weight relationship and diet of African carp, *Labeo ogunensis* (Boulenger, 1910) in Asejire lake, Southwestern Nigeria. *Journal of Fisheries and Aquatic Science*, 6:472-478
- Ayotunde, E.O., Ochang, S.N. and Okey, I.B. (2007). Parasitological examinations and food composition in the gut of feral African carp, *Labeo coubie* in the Cross River, Southeastern Nigeria.. *African Journal of Biotechnology*, 6(5):625-630
- Azeroual, A, Entsuah-Mensah, M., Getahun, A., Hanssens, M., Laleye, P., Moelants, T. and Twongo, T. (2010). *Labeo coubie*. The IUCN red list of threatened species 2010; e T182352A 7866561. [http:// dx. Doi.org/10.2305/IUCN.UK. 2010 – 3. RLTS. T182352A7866561.en](http://dx.doi.org/10.2305/IUCN.UK.2010-3.RLTS.T182352A7866561.en). downloaded on 10th December,2019
- Bagenal, T.B. and Tesch, F.W.(1978). Age and Growth. Bagenal, T.B. ed. *Methods of assessment of fish production in freshwater*. Blackwell Scientific Publication, Oxford. IBP Handbook No. 3.101-136
- Barron, J., Galliard, J., Ferriere, R. And Tully, T. (2012). Intermittent breeding and the dynamics of resource allocation to reproduction, growth and survival. *Functional Ecology* 27:173-183
- Bolarinwa, J.B. (2017). Length-weight relationship and condition factor of *Cynoglossus cynoglossus* and *Caranx hippos* in Epe Lagoon, Nigeria. *International Journal of Research in Agriculture and Forestry*, 4(5):1-5
- Ikpi, G.U., Jenyo-Oni, A. and Offem, B.O. (2012). Catch rate, distribution, trophic and reproductive biology of the African carp, *Labeo coubie* in the Agbokim Waterfalls, Nigeria. *Fisheries and Aquaculture Journal* 2012: FAJ-38 14pp
- Ikape, S.I. and Solomon, S.G. (2018). Filleting yield, body characteristics and length-weight relationship of four fish species from Lower River Benue, Makurdi, Nigeria. *Aquatic Research*, 1(3):115-126
- Laleye, P.(2006). Length-weight and length-length relationships of fishes from Queme River in Benin (West Africa). *Journal of Applied Ichthyology*, 22:330-333
- Rodrigues, K.A., Macchi, G.J., Massa, A. And Militelli, M.I. (2013). Seasonal analysis of condition, biochemical and bioenergetic indices of females of Brazilian flathead, Olufeagba, S.O. and Okomoda, V.T. 2016. Some aspects of biology of *Labeo coubie* Ruppell, 1832 and *Labeo senegalensis* Valenciennes 1842 from Lower River Benue. *Journal of Fisheries Science* 10.2:49-54 *Percophis brasiliensis*. *Neotropical ichthyology* 11(1):153-162

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Bioaccumulation of Heavy Metals concentration in mackerel (*Scomber japonicus*) purchased from Ijora Fish Market, Lagos State, Nigeria

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Abstract

Bioaccumulation of heavy metals in fish causes a serious threat to the human health when they consume heavy metal polluted fish. Thus, detection of the toxic element concentration level in fish is important. These metals zinc (Zn), copper (Cu), cadmium (Cd), chromium (Cr), iron (Fe), nickel (Ni), manganese (Mn), lead (Pb) and cobalt (Co) in imported mackerel fish sample were analyzed with atomic absorption spectrometer (AAS). The mean concentration of Cu, Fe, and Ni was 0.8, 6.86 and 2.26 mg/Kg respectively. Zn, Cd, Cr, Mn, Pb and Co was below the detection limit. Order of heavy metal concentration was observed as Fe>Cu>Ni. The concentration of Fe, Ni, Cu were higher than the permissible limit. This indicates risk for human consumption.

Keywords: Heavy Metals, Concentration, mackerel, Ijora

Introduction

The consumption of fish worldwide has increased speedily in recent years particularly with the awareness of its nutritional and therapeutic benefits. In addition to being an important source of protein, fish is enriched with essentials minerals, vitamins, and unsaturated fatty acids (US Department of health and human services and US Department of Agriculture, 2015). According to the food and Agriculture Organization (FAO), (2020). World fish production has increased dramatically during the past 60 years, to around 179 million tons in 2018 with a value of \$401 billion. Global fish consumption also increased from 9.0kg per capita in 1961 to 20.5kg in 2018. Fishes occupy higher trophic levels in the food chain; they are considered one of the most common bio-indicators for pollutants (Rajeshkumar and LI, 2018).

Heavy metals have been defined as "naturally occurring metals having an atomic number greater than 20 and an elemental density greater than 5g /cm⁻³ (Ali and Khan, 2018). Heavy metals are a natural trace component of the aquatic environment whose levels have been reported to be on the increase in recent times due to pollution from water, anthropogenic activities, as the industrial wastewater discharges via river and domestic waste without any treatment (Bat *et al.*, 2018). The increasing use of Heavy metals in the industry has led to an increase in the release of harmful heavy metals into the aquatic environment (Ogugwah and Ikegwu, 2017).

Contamination of fish by heavy metals has become an important global issue because it presents a threat to fish and poses health risks to fish consumers (Yousafzai *et al.*, 2017). The toxicity level may affect human health, animals, plants and aquatic organism (Yadav *et al.*, 2018). However, due to some health issues that may be associated with heavy metal contamination in fish, many international monitoring programs have been created to evaluate the heavy metal concentrations and nutritional value of fish before consumption (Marriott *et al.*, 2020). This study was therefore carried out to determine the concentration of some heavy metal in mackerel purchased from the Ijora fish market.

Materials and Methods

Sample collection and preparation

Mackerel were bought from the fish sellers at the Ijora fish market, Lagos State, Nigeria. The samples were placed in a pre-washed polyethylene bag and taken in an ice-cold box to the Marine Biology Department of the Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos for proper identification. In the laboratory, they were weighed and measured with sensitive weighing scale. The average weight was 400 g while the average length was 37.6cm. They were kept at -20°C until analysis.

Analysis of Heavy Metals

The wet method of digestion was used to carry out the sample digestion. Frozen fish samples were thawed, the fish weight and total length were taken, before dissecting for analysis. Exactly 5.0g of the homogenized samples were weighed and digested with 25ml of 6N nitric acid. The extracts were analyzed for zinc (Zn), copper (Cu), cadmium (Cd), chromium (Cr), iron (Fe), nickel (Ni), manganese (Mn), lead (Pb) and cobalt (Co) using Scientific flame atomic absorption spectrophotometer-ASS (Varian Spectrophotometer AA 600 model) as described by (U.S. EPA) (1996). All reagents used were of analytical grade. Distilled water was used for solutions preparation and dilutions. All glassware was soaked in 10% nitric acid for 24 hours and later rinsed with distilled water before use for metal analysis.

Result and Discussion

In the present study, the result of mean heavy metal concentration (mg/kg) in the muscle of mackerel is shown in table 1. The muscle of the fish contained Zn, Cu, Cd, Cr, Fe, Ni and Mn at different concentrations. The order of heavy metal concentration was observed as Fe>Cu>Ni. The presence of Ni is still within the permissible limit for fish WHO/FAO, (1989); UNEP, (2002). The Fe concentration is moderate, because is equally a trace metal needed by humans. The concentration of Cu in the fish muscle needs to be monitored because of the health effect it can cause on consumers.

Table I: Heavy metals concentrations in the muscle tissue of mackerel in mg/Kg

Heavy Metals	Concentration (mg/kg)	Permissible limit (FAO/WHO/UNEP)
Zn	BDL	0.3- 1.0
Cu	0.8	0.4
Cd	BDL	0.03
Cr	BDL	2.3
Fe	6.86	4.0
Ni	2.26	70-80
Mn	BDL	1.0
Pb	BDL	0.3
Co	BDL	0.015

This variation might be due to the level of bioaccumulation, which can be a function of species, PH, temperature and trophic transfer as reported by Oguguah and Ikegwu, (2017). Furthermore, Khaid, (2004) suggested that heavy metal concentration could also be a result of the environment where the fish was caught or the age of the fish. It is imperative to note that Cu is one of the essential metals needed to help enzymatic activities in the animal system (Voegborlo *et al.*, 2012). The acute symptoms of copper contamination by ingestion include vomiting, hematemesis (vomiting blood), and gastrointestinal distress (Bawuro *et al.*, 2018). A higher result of Cu in fish muscle (1.27) was recorded by Bawuro *et al.*, (2018). Iron (Fe) is essential metal needed by fish for blood production (Ali and Khan, 2019). The result of the heavy metals concentrations in this study has shown that mackerel fish studied in this present work indicates risk for human consumption.

Conclusion

This study showed that Cu, Fe and Ni were present in the muscle tissue of mackerel at a concentration above the regulatory standard [FAO\WHO] which indicate risk for human consumption. This study recommends continuous monitoring and proper quality control of fish imported and sold in the Ijora market.

References

- Ali H. and Khan, E. (2019). Tropical transfer bioaccumulation and biomagnification of non-essential hazardous heavy metals and metalloids in food chains/webs concepts and implications for wildlife and human health, Human and Ecological Risk. Assessment: *An International Journal*, 25:6, 1353-1376.
- Ali H. and Khan, E. (2018a). Bioaccumulation of non - essential hazardous heavy metals and metalloids in freshwater fish. Risk to human health. *Environmental Chemistry Letters*. 16(3): 903-917.
- Bat, I., Oztekin, A., Sahin, F., Arici, E. and Ozsandikci U (2018). An overview of the Black Sea pollution in Turkey. *MedFAR*. 1(2): 67-86.

- Bawuro, A.A., Voegborlo, R.B. and Adimado, A.A. (2018). Bioaccumulation of Heavy Metals in Some Tissues of Fish in Lake Geriyo, Adamawa State, Nigeria. *Journal of Environmental and Public Health*. Article ID 1854892, 7.
- FAO (2020). The state of world fisheries and Aquaculture. Sustainability in action. Rome.
- FAO/WHO (1989). WHO technical report series No.505, Evaluation of certain food additives and the contaminants lead and cadmium for environment monitoring report No.52 Centre for the environment, Tech. Rep. Fisheries and *aquatic Science lowest To fit the UK*.
- Khalid, A. (2004). Seasonal determination of soil heavy metals on muscles tissues of *Siganus revolutus* and *Sargus spp* from EL-Mex bay and Eastern Harbor, Alexandria. Egypt. *Egyptian Journal of Aquatic Biology and Fisheries* 81.
- Marriott, A.L. Kelly, T.J., Sarka, S.K. (2020). Elemental composition of fish from West Bengal India. Nutrition versus food safety. *Environmental Geochemistry and Health*, 42, 1211-1228.
- Oguguah, N.M. & Ikegwu, M.O. (2017). Concentration and Human Health Implication of trace Metals in fish of economic importance in Lagos lagoon, Nigeria. *J. Health pollution* 13:66-72.
- US Department of Health and Human Services and US Department of Agriculture. 2015-2020. Dietary Guidelines for Americans, 8th Edition.
- Rajeshkumar S. And X. LI (2018). Bioaccumulation of heavy metals in fish species from the Meiliang bay, Taihu, Lake, China. *Toxicology Reports*, vol. 5, pp.288-295, 2018.
- Voegborlo R.B., Atta, A. and E.S. Agorku 2012. "Total mercury distribution in different tissues of six species of fish from the Kpong hydroelectric Reservoir in Ghana". *Environmental Modeling and Assessment* 184 (5) 32.
- United Nations Environment Program (UNEP), (2002). *Central America and the Caribbean Regional Report, Regionally Based Assessment of Persistent Toxic Substances*, Geneva Switzerland.
- The United States Environmental Protection Agency (1996). "Method 3050B: Acid Digestion of Sediments, Sludges, and Soils," Revision 2. Washington, DC.
- Yadava K.K. Gupta, N.Kumar, V. Khanb, S.A. Kumara, A.(2018). A review of emerging adsorbents and current demand for defluorination water. Bright future in water sustainability. *Environment International*. 1(1): 80-108.
- Yousafzai A.M. Ullah. F. Aput nd Bari F. 2017. Bioaccumulation of some heavy metals analysis and comparison of *Cyprinus carpio* and *Laeorohita* from Sardaryabkhyberpakhtunkhwa, "Biomed Research International, vol. 2017. Article ID

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Heavy Metal Concentration in the Muscle Tissue of Imported (Senegalese hake) *Merluccius senegalensis* from Ijora Fish Market, Lagos State, Nigeria

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Abstract

The fishery products are considered important in human nutrition due to their unique properties. However, the bioaccumulation of toxic metals at the high concentration by fishes from their environment is of major concern. This study aims to determine the concentrations of some toxic metals such as zinc (Zn), copper (Cu), cadmium (Cd), chromium (Cr), iron (Fe), nickel (Ni), manganese (Mn), lead (Pb) and cobalt (Co) in the muscle tissue of Senegalese hake imported into Nigeria, Lagos State precisely and to ascertain whether the concentrations of these pollutants are below the maximum levels established by FAO/WHO. This heavy metal concentration was analysed using a Scientific flame atomic absorption spectrophotometer (Varian Spectrophotometer AA 600 model). Cu, Fe, Ni and Mn was found to be 0.38, 3.2, 1.83 and 1.02 mg/Kg respectively, while Zn, Cd, Cr, Pb and Co were found to be below the detection limit. In comparison with FAO/WHO, all metals considered were below the maximum permissible limits as recommended by the United Nations Environment Program (UNEP), Food and Agriculture Organization (FAO) and World Health Organization (WHO), for heavy metals in fish.

Keywords: Heavy metals; Fish, Human nutrition; Pollutants

Introduction

Pollution of the aquatic environment has become alarming and serves as a research study due to its effect on the water quality as well as the aquatic ecosystem. Pollution by heavy metals is an important problem in the aquatic ecosystem worldwide (Olusola and Festus, 2015). These heavy metals can remain in solution or suspension and precipitate on the bottom or be taken up by the microorganism (Perugini, *et al.*, 2014; Abraham-Olukayode *et al.*, 2019). The increase in pollution by heavy metals has been traced to an increase in population, industrialization, and agricultural practices (Olusola and Festus 2015; Oguguah and Ikegwu, 2017). Heavy metals are absorbed by the fishes from the surroundings depending on various factors such as the species of the fish, the concentration of the heavy metals in the water, exposure period and abiotic factors (temperature, salinity, pH and season change (Perugini, *et al.*, 2014). Increasing numbers of imported seafood products into the Nigerian market has prompted evaluation of the safety of these products. *Merluccius senegalensis* also known as Senegalese hake (or true hake) is found in the subtropical waters of the eastern Atlantic Ocean off the northwest coast of Africa. The objectives of the present investigation are to determine the concentrations of some toxic metals (Zn, Cu, Cd, Cr, Fe, Ni, Mn, Pb and Co) in the muscle tissue of *Merluccius senegalensis* imported into Lagos State, Nigeria, and to ascertain whether the concentrations of these pollutants are below the maximum levels established by relevant authorities such as FAO, UNDP and USEPA.

Materials and Methods

Reagent/apparatus: All reagents used were of analytical grade. Distilled water was used for solutions preparation and dilutions. All glassware was pre-acid washed by soaking in 10% HNO₃ for 24 hours and later rinsed with distilled water before use for metal analysis.

Sample collection and preparation: Frozen Senegalese hake samples were purchased from the Ijora fish market in Lagos. The samples were transported aseptically in a polythene bag in an insulated icebox to Nigerian Institute for Oceanography and Marine Research, Victoria Island Lagos State. The fish sample was dissected, ground and homogenized for analysis.

Sample analysis: Five grams (5 g) of the homogenized sample was weighed and digested in 50 ml of 6N HNO₃ for 6 - 8 h in compliance with the FAO method. The solution was analysed by a scientific flame atomic absorption spectrophotometer (Varian Spectrophotometer AA 600 model). Samples were run in batches which included blank, a standard calibration curve, and samples solutions in duplicate which are prepared with the same

reagents. Heavy metals analysed include zinc (Zn), copper (Cu), cadmium (Cd), chromium (Cr), iron (Fe), nickel (Ni), manganese (Mn), lead (Pb) and cobalt (Co). All metal concentrations were determined based on milligrams per kilogram.

Results and Discussion

Metal concentrations in Senegalese hake are summarized in Table 1. Metal accumulation followed the order Fe>Ni>Mn>Cu>Zn=Cd=Cr=Pb=Co. Cu, Fe, Ni, Mn was found to be 0.38, 3.2, 1.83, 1.02 mg/Kg respectively while Zn, Cd, Cr, Pb and Co were found to be below the detection limit.

Table 1: Heavy metals concentration (mg/Kg) in the muscle of Senegalese hake (*Merluccius senegalensis*)

Heavy Metals	Concentration (mg/Kg)	FAO/WHO (mg/Kg)
Zn	BDL	0.3-1.0
Cu	0.38	0.4
Cd	BDL	0.03
Cr	BDL	2.3
Fe	3.2	4.0
Ni	1.82	70-80
Mn	1.02	1.0
Pb	BDL	0.3
Co	BDL	0.015

* Key: BDL means below detection limit

These results could be as a result of the level of bioaccumulation of the metals by the species of fish of study Senegalese hake. It was seen that all results obtained falls within the range specified by the FAO (1983)/WHO (2012). Results obtained in this study are similar to those obtained by El Hraiki *et al.*, (1992,1993) from Morocco and Smolikova *et al.*, (2016) from the Czech Republic. Zinc, an essential element, is required in the human diet to maintain the immune system (Dhanakumar *et al.*, 2015; Abraham-Olukayode *et al.*, 2019) but its high concentration can lead to renal damage, vomiting, cramps and so on. Cu is also an essential element that can serve as an enzyme as well as metalloproteins but its high concentration can lead to anaemia, kidney and liver dysfunction and vitamin C deficiency (Lokeshappa *et al.*, 2012). Cadmium is a non-essential heavy metal in foods and natural water which accumulates in the kidney and liver (Adesuyi *et al.*, 2016). Excess Pb in the body system can be related to heart disease and cancer, but in low concentration can be used for biological functions. Ni is also an essential metal but when in high concentration can be carcinogenic, and can also lead to fibrosis, tumour, lung inflammation, and emphysema (Azman *et al.*, 2015).

Conclusion

The results of the findings of this study present baseline information on heavy metals concentration in Senegalese hake sourced from Ijora Fish market, Lagos Nigeria. The concentrations of the heavy metals analyzed for in Senegalese hake did not exceed the permissible limit of heavy metals as recommended by the FAO and WHO, for heavy metals in fish, however, there is a need for regular monitoring of heavy metals concentrations in fish so that human health is not at risk.

References

- Abraham-Olukayode, A. O., Egbe, F. C., Musa, M., Rayyan, S. H., Olajuyigbe, O. O., Oramadike, C. E., Aborisade, A.B., Yusuf, H., Adejonwo, O. A. (2019). Heavy metal concentration in the muscle of blue crab (*Collinectes amnicola*). 53rd Annual Conference Proceedings of Agricultural Society of Nigeria, 102-104.
- Adesuyi, A. A., Ngwoke, M. O., Akinola, M. O., Njiku, K. L., and Jolaoso, A. O. (2016). Physicochemical assessment of sediments from Nwaja Creek, Niger Delta Nigeria. *Journal of Geoscience and Environment Protection*, 4: 16-27.
- Azman, F., Juahira, H., Yunus, K., Azid, A., Kamarudin, M. K. A., Toriman, M. E., Mustafa, A. D., Amran, M. A., Hasnam, C. N. C. and Saudi, A. S. M. (2015). Heavy metal in fish: Analysis and human health-a review. *Jurnal Teknologi (Sciences & Engineering)*, 77(1): 61–69.
- Dhanakumar, S., Solaraj, G., and Mohanraj, R. (2015). Heavy metal partitioning in sediments and bioaccumulation commercial fish species of three major reservoirs of river Cauvery delta region, India. *Ecotoxicol Environ Safety*, 113:145-151.

- El Hraiki,A., Kessabi,M., Sabhi,Y., Buhler,D. R. and Benard,P. (1993). Chapter III: Cadmium, lead and mercury in Moroccan fishery products from the Mediterranean Sea. In: A thesis on assessment of chlorinated hydrocarbons and trace metal contamination of Moroccan Marklespades. Published in Landwirtschaftliches, Jahrbuch 69, jhrg. sonderheft 1/92; 113-118.
- El Hraiki,A., Kessabi,M., Sabhi,Y., Benard,P.And Buhler,D. R. (1992). Chapter IV: Contamination of Moroccan fishery products by cadmium, chromium, lead, and mercury. In: A thesis on assessment of chlorinated hydrocarbons and trace metal contamination of MoroccanMarklespades. Published in French: Revue de Medicine Veterinaire, 1992, 143:49-56.
- FAO (1983). Compilation of illegal limit for hazardous substances in fish and fishery products. FAO fisheries circular, No 464, food and agricultural organisation, Rome.
- Lokeshappa, B., Shivpuri, K., Tripathi, V and Dikshit A.K. (2012). Assessment of toxic metals in agricultural produce. *Food and Public Health*, 2(1): 24-29.
- Olusola, J. O., Festus, A. A (2015). Assessment of Heavy Metals in Some Marine Fish Species Relevant to their Concentration in Water andSediment from Coastal Waters of Ondo State, Nigeria. *J Marine Sci Res Dev*, 5: 163
- Oguguah, N. M. and Ikegwu, M. O. J. (2017). Concentration and Human Health Implications of Trace Metals in Fish of Economic Importance in Lagos Lagoon, Nigeria. *J Health Pollution*, 13: 66-72.
- Perugini, M.,Visciano, P.,Manera, M.,Zaccaroni, A., Olivieri, V.and Amorena, M. (2014). Heavy metal (As, Cd, Hg, Pb, Cu, Zn, Se) concentrationsin muscle and bone of four commercial fish caughtin the central Adriatic Sea, Italy. *Environ Monit Assess*, 186:2205–2213.
- Smolikova, V., Ridoskova, A., Pelcova, P. (2016). Determination of heavy metals in fish products. *Mendelnet*, 651-656.
- WHO (World Health Organisation) (2012). Codex Alimentarius Committee. Joint FAO/WHO Food standards Programme. Codex Committee on contaminants in food. The sixth session, Maastricht, Netherland, 26-30.

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Seasonal Changes in Haematological Values of Male and Female African Snakehead (*Parachanna obscura*) from Eleyele Reservoir, Ibadan, Nigeria

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Abstract

The aim of the present study was to investigate the seasonal changes in haematological values for male and female African snakehead, *Parachanna obscura* (Channidae) from Eleyele Reservoir, Nigeria. White blood cells ($26.13 \pm 1.01 \times 10^3 \mu\text{l}^{-1}$), monocytes ($3.54 \pm 0.21 \%$), neutrophils ($35.79 \pm 1.59 \%$) and platelets ($27.45 \pm 14.33 \times 10^3 \mu\text{l}^{-1}$) were significantly higher ($P < 0.05$) in female, while lymphocytes ($71.45 \pm 2.04 \%$) was markedly higher in male. Haematological values were not significantly different ($P > 0.05$) between seasons, however, white blood cell ($26.13 \pm 1.01 \times 10^3 \mu\text{l}^{-1}$), lymphocyte ($58.39 \pm 1.80 \%$), neutrophils ($35.79 \pm 1.59 \%$), monocytes ($3.54 \pm 0.21 \%$), platelets ($27.45 \pm 14.33 \times 10^3 \mu\text{l}^{-1}$) and mean corpuscular hemoglobin ($35.97 \pm 1.11 \text{ pg}$) were marginally higher ($P < 0.05$) in dry season samples. This result implies that haematological parameters of *P. obscura* are more influenced by sexual differences than seasonal changes.

Key words: *Parachanna obscura*, haematology, biochemistry, sex, season, Eleyele Reservoir.

Introduction

Blood is the most important fluid in the body and its composition often reflects the total physiological condition of an organism (Bahmani *et al.*, 2001). Blood analysis has therefore become essential as an indicator of physiological or pathological changes in fisheries management and disease investigations. Fish live in water and they are extremely dependent upon it, any changes in the environment would affect their physiology. This situation then poses a great concern to safety of inland fishery resources from environmental contamination or pollution. According to Fagbenro *et al.* (2000), the knowledge of the haematological profile of a fish could provide information on dietary sufficiency and physiological response to environmental stress. It also gives the haematological picture of species in their natural environment so that values of each species could be standardized for subsequent verification of factor inducing changes (Bindu Bhaskaran, 2011). These changes depend on fish species, age, the cycle of the sexual maturity of spawners and diseases (Ipinmoroti, 2015). Haematological analyses provide clue on haemoglobin, red cells, white cells, haematocrit, platelet count and erythrocyte sedimentation rate (Newman *et al.*, 1997). Haemoglobin decreased by anaemia or increased by prolonged physical stress. The packed cell volume gives an indication of red cell concentration in a sample of blood (Blaxhall and Daisley, 1973). It is usually reduced in anaemic condition or after a major haemorrhage. The haematological profile of *Parachanna obscura* (Odedeyi, 2013; Odoet *et al.*, 2012; Kori-Siakpere *et al.*, 2005) have been reported. However, sex and seasonal variations in blood parameters of this species have not been succinctly documented. Therefore, this study investigates seasonal variation in haematological values of male and female *Parachanna obscura* from Eleyele Reservoir.

Materials and Methods

A total of 72 male and female *Parachanna obscura* ($382.42 \pm 59.41 \text{ g}$) were collected from the fish landing site at Eleyele Reservoir, southwestern Nigeria (Latitude $7^{\circ}25'0'' - 7^{\circ}26'15'' \text{ N}$ and Longitude $3^{\circ}50'45'' - 3^{\circ}52'15'' \text{ E}$) between April 2015 and March 2016. The sex of each specimen was determined by examination of the genitals for testis or ovaries. Fish samples were transported to the laboratory within one hour after collection. Blood samples collection and analysis for haematological studies was done following the procedure of Ajani *et al.*, (2016).

Red blood cell and White blood cell were determined using a Neubauer hemocytometer (Kaplow, 1955), while differential white cell count was done on blood films stained with Giemsa. The different types of leucocytes were determined on each blood smear and a mean relative percent calculated. Replicate counts were made for each blood sample. The micro-hematocrit method was used for the determination of packed cell volume (Blaxhall and Daisley, 1973) while Haemoglobin was determined using the cyanmethaemoglobin method (Dacie and Lewis, 1976). Mean corpuscular volume was calculated according to Feldman *et al.* (2000). Mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration were calculated according to Stoskopf (1993).

Dry season samples covered November–April and while rainy seasons covered May–October (Isehunwa and Alada, 2013). The ambient temperature was measured throughout the period of the study as $25.5 \pm 1.74^\circ\text{C}$ for the rainy season and $28.2 \pm 2.34^\circ\text{C}$ for dry season. Results were analysed using descriptive statistics and t-test, at 5% of confidence level.

Results

The haematological values of male and female *P. obscura* are presented in Table 1. It is evident that, no significant difference ($p > 0.05$) exists in the Red blood cell, Packed cell volume, Haemoglobin, Eosinophils, Basophils, Mean corpuscular volume (MCV) and Mean corpuscular haemoglobin concentration (MCHC) between sexes. White blood cells ($26.13 \pm 1.01 \times 10^3 \mu\text{l}^{-1}$), Monocytes ($3.54 \pm 0.21 \%$), Neutrophils ($35.79 \pm 1.59 \%$) and Platelets (27.45 ± 14.33) were significantly ($p < 0.05$) higher in female than their male counterpart. Similarly, the hematological results showed non-significant differences in values ($p > 0.05$) between seasons (Table 2). However, red blood cell ($3.46 \pm 0.08 \times 10^6 \mu\text{l}^{-1}$), packed cell volume ($31.94 \pm 0.99 \%$), haemoglobin ($11.52 \pm 0.19 \text{ g dl}^{-1}$), eosinophils ($5.59 \pm 0.18 \%$) and basophils ($0.09 \pm 0.01 \%$) were slightly higher in wet season.

Table 1: Sex variation in mean values of haematological parameters of *P. obscura* (n = 36 per sex)

Haematological Parameters	Male		Female		Sig. value
	Range	(Mean $\pm$ SE)	Range	(Mean $\pm$ SE)	
RBC ($10^6 \mu\text{l}^{-1}$)	1.98 – 4.13	3.29 ± 0.07	2.21 – 4.38	3.43 ± 0.08	0.19
WBC ($10^3 \mu\text{l}^{-1}$)	17.41 – 37.18	23.02 ± 0.68	16.12 – 41.25	26.13 ± 1.01	0.01*
PCV (%)	19.88 – 43.78	32.05 ± 1.07	20.62 – 42.88	30.46 ± 1.13	0.31
Haemoglobin (g dl^{-1})	7.95 – 15.21	11.70 ± 0.29	8.46 – 13.38	11.09 ± 1.17	0.09
Lymphocytes (%)	39.52 – 88.63	71.45 ± 2.04	36.56 – 78.23	58.39 ± 1.80	0.00*
Monocytes (%)	1.47 – 5.31	2.85 ± 0.16	1.26 – 6.52	3.54 ± 0.21	0.01*
Neutrophils (%)	12.37 – 53.55	25.40 ± 1.44	15.73 – 52.36	35.79 ± 1.59	0.00*
Eosinophils (%)	3.45 – 8.81	5.36 ± 0.21	3.53 – 8.42	5.35 ± 0.18	0.98
Basophils (%)	0.00 – 0.24	0.09 ± 0.01	0.00 – 0.23	0.08 ± 0.00	0.50
Platelets ($10^3 \mu\text{l}^{-1}$)	12.15 – 35.41	21.39 ± 11.31	10.367 – 43.82	27.45 ± 14.33	0.00*
MCV (fl)	54.46 – 199.54	100.80 ± 4.86	47.07 – 138.81	90.85 ± 4.30	0.13
MCH (pg)	25.78 – 56.46	35.97 ± 1.11	25.45 – 44.07	32.82 ± 0.81	0.02*
MCHC (g dl^{-1})	20.33 – 65.54	38.10 ± 1.67	19.75 – 59.94	38.32 ± 1.66	0.92

Key: RBC red blood cell, WBC white blood cell, PCV packed cell volume, MCV Mean corpuscular volume, MCH Mean corpuscular haemoglobin, MCHC Mean corpuscular haemoglobin concentration. *Significant at 5% level ($P < 0.05$)

Table 2: Seasonal variation in mean values of haematological parameters of *P. obscura*

Haematological Parameters	Dry Season		Wet Season		P value
	Range	(Mean $\pm$ SE)	Range	(Mean $\pm$ SE)	
RBC ($10^6 \mu\text{l}^{-1}$)	1.98 – 4.24	3.26 ± 0.08	2.21 – 4.38	3.46 ± 0.08	0.69
WBC ($10^3 \mu\text{l}^{-1}$)	16.82 – 41.25	25.18 ± 0.96	16.12 – 35.57	23.97 ± 0.82	0.34
PCV (%)	19.88 – 42.88	30.57 ± 1.21	20.62 – 43.78	31.94 ± 0.99	0.39
Haemoglobin (g dl^{-1})	7.95 – 15.21	11.28 ± 0.30	9.49 – 14.98	11.52 ± 0.19	0.51
Lymphocytes (%)	36.56 – 88.63	67.41 ± 2.23	36.76 – 82.21	62.43 ± 2.13	0.11
Monocytes (%)	1.47 – 6.52	3.27 ± 0.22	1.26 – 6.43	3.12 ± 0.17	0.59
Neutrophils	14.79 – 53.55	32.53 ± 1.81	12.37 – 50.32	28.67 ± 1.62	0.12
Eosinophils	3.45 – 8.81	5.13 ± 0.22	3.53 – 7.36	5.59 ± 0.18	0.11
Basophils (%)	0.00 – 0.24	0.07 ± 0.01	0.00 – 0.21	0.09 ± 0.01	0.14
Platelets ($10^3 \mu\text{l}^{-1}$)	13.51 – 41.13	25.32 ± 13.06	10.36 – 43.82	23.52 ± 14.50	0.36
MCV (fl)	53.00 – 199.54	97.40 ± 5.26	47.07 – 138.98	94.25 ± 3.98	0.64
MCH (pg)	25.54 – 56.46	35.15 ± 1.23	25.45 – 44.07	33.64 ± 0.71	0.29
MCHC (g dl^{-1})	19.75 – 65.54	39.25 ± 2.01	25.57 – 54.07	37.17 ± 1.21	0.38

Key: RBC red blood cell, WBC white blood cell, PCV packed cell volume, MCV mean corpuscular volume, MCH mean corpuscular haemoglobin, MCHC mean corpuscular haemoglobin concentration, *Significant at 5% level ($P < 0.05$)

Discussion

The haematological values observed in this study were consistent with previous report on some freshwater teleost (Abalaka, 2013; Owolabi, 2011; Kori-Siakpereet *et al.*, 2005; Hrubecet *et al.*, 2000). White blood cell, monocytes and neutrophils were found to be notably higher in female *P. obscura*. This could be due to increase in reproductive activity and defense mechanisms of female fish. However, marked differences in lymphocyte counts were observed in favour of males. This observation is in accordance with the findings of Ejraei *et al.* (2015) and Kohanestani *et al.* (2013). Also, several authors including Owolabi (2011) and Akinrotimiet *et al.* (2007) reported higher value of packed

cell volume and hemoglobin count in males than female fish. This may be as a result of higher physiological activity of male than the female fish. Also, Summerfelt *et al.*, (1967) report increase packed cell volume in male fish approaching spawning. Whereas, Joshi (1973) posited that higher haematological values in male are primarily due to its being biochemically and nutritionally richer than the female.

Contrastingly, the study revealed slight seasonal changes on the hematological values of *P. obscura*. The Red blood cell, packed cell volume, haemoglobin, eosinophil and basophils were higher in wet season. A similar observation was made for packed cell volume and haemoglobin in *P. obscura* from Ose River (Odedeyi, 2013). Also, higher white blood cell, lymphocyte, monocytes, and neutrophil were recorded in summer and autumn for *Alburnoidesichwaldii* (Kohanestani *et al.*, 2013). Season related hematological changes have also been reported earlier by Nwabueze and Regha-John (2015), and BinduBhaskaran (2011).

Conclusions

This study revealed marked sex variation on white blood cell, lymphocyte, monocyte, neutrophils and platelets, while seasonal influence was marginally observed. Therefore, the study shows that haematological values of *P. obscura* were more affected by sex than season.

References

- Abalaka, S.E. 2013. Evaluation of the Haematology and Biochemistry of *Clarias gariepinus* Biomarkers of Environmental Pollution in Tiga dam, Nigeria. *Braz. Arch. Biol. Technol.* 56(3): 371-376.
- Ajani E.K, Olanrewaju, A.N. and Kareem, O.K. 2016. Hematological and Immunological Changes in the Blood of African Catfish (*Clarias gariepinus*, Burchell 1822) Reared under different Sex Combinations. *Hematologia*, 5(1): 1–5. <https://scialert.net/fulltext/?doi=hematol.2016.1.5>
- Akinrotimi, A. O. Gabriel, U.U., Anyanwu, P.E. & Anyanwu, A.O. (2007). Influence of sex, Acclimation Methods and Period on Haematology of *Sarotherodon melanotheron* (cichilidae). *Research Journal of Biological Sciences*, 2(3), 348-352.
- Bahmani, M., Kazemi, R. and Donskaya, P. 2001. A comparative study of some hematological features in young reared sturgeons (*Acipenser persicus* and *Huso huso*). *Fish Physiol. Biochem.*, 24: 135-140.
- BinduBhaskaran, A.B. 2011. Haematological and toxicological studies on brackish water fish, *Etroplus maculatus* (Bloch). Ph.D Thesis submitted to Department of Marine Biology, Microbiology and Biochemistry, School of Marine Sciences, Cochin University of Science and Technology, Kochi-682016, India. Pp. 299
- Blaxhall, P. C. and Daisley, K. W. 1973. Routine haematological methods for use. *Fish Blood. J Fish Biol.*, 5: 771–781.
- Dacie, J.V. and Lewis, S.M. 1976. *Practical Hematology*. Longman Group. Ltd. Pp. 78–97
- Ejraei, F., Ghiasi, M. and Khara, H. 2015. Evaluation of hematological and plasma indices in grass carp, *Ctenopharyngodon idella*, with reference to age, sex, and hormonal treatment. *Arch. Po Fish.*, 23: 163-170.
- Fagbenro, O., Adedire, C.O., Ayotunde, E.O. and Faminu, E.O. 2000. Haematological profile, food composition and enzyme assay in the gut of the African bony-tongue fish, *Heterotis (Clupisudis) niloticus* (Cuvier 1829) (Osteoglossidae). *Trop. Zool.*, 13: 1-9.
- Feldman, B.F., Zinkl, J.G. and Jain, N.C., 2000. *Schalm's Veterinary Haematology*. 5th ed. Lippincott Williams and Wilkins. pp. 1120-1124.
- Hrubec, T.C., Cardinale, J.L. and Smith, S.A. 2000. Haematology and Plasma Chemistry Reference Intervals for Cultured Tilapia (*Oreochromis Hybrid*). *Veterinary Clinical Pathology* 29(1): 7 – 12.
- Ipinmoroti, M.O. 2015. Variation in the Blood Constituents of Catfish (*Clarias gariepinus*, Burchell 1822) Caught from Different Habitat. *International Journal of Scientific Research in Environmental Sciences* 3(6): 0226-0233.
- Isehunwa, O.G. and Alada, A.R.A. 2013. Seasonal and sex variation in the blood parameters of the common African toad *Bufo regularis*. *Canadian Journal of Pure and Applied Sciences* 7(3): 2537-2539.
- Joshi, B.D. 1973. Studies on the blood of fresh water fishes of India. Ph.D thesis. Univ. of Lucknow, India.
- Kaplow, L.S. 1955. A histochemical procedure for localizing and valuating leukocyte alkaline phosphatase activity in smears of blood and marrow. *Blood* 10: 1023-1029.
- Kohanestani, Z.M., Hajimoradloo, A., Ghorbani, R., Yulghi, S., Hoseini, A. and Molaei, M. 2013. Seasonal variations in hematological parameters of *Alburnoidesichwaldii* in Zaringol Stream-Golestan Province, Iran. *World. J. Fish. Mari. Sci.*, 5: 121-1262.
- Kori-Siakpere, O., Ake, J.E.G. and Idoge, E. 2005. Haematological characteristics of the African snakehead, *Parachanna obscura*. *Afri J Biotech.*, 4(6): 527–530.

- Newman, S. H., Piatt, J. F. and White, J. 1997. Haematological and plasma biochemical reference ranges of Alaskan seabirds: their ecological significance and clinical importance. *Waterbirds* 20(3): 492–504.
- Nwabueze, A.A. and Regha-John, J. 2015. Seasonal variations in Serological profiles and growth status of farmed and wild *Clarias gariepinus* (Burchell, 1822) obtained from Asaba, Nigeria. *Journal of Agricultural Science and Technology* B5: 205-215
- Odedeyi, D.O. 2013. Seasonal, sex and size variation in some blood parameters of snakehead (*Parachanna obscura*, Gunther 1861) in Ose River, Southwest–Nigeria. *Global Journal of Biology, Agriculture and Health Sciences* 2(4): 107-110.
- Odo, G.E., Onoja, S.U. and Onyishi, G.C. 2012. The biology of *Parachanna obscura* (Osteichthyes: Channidae) in Anambra River, Nigeria. *International Journal of Fisheries and Aquaculture* 4(8): 154-169.
- Owolabi, O. D. 2011. Haematological and serum biochemical profile of the upside-down catfish, *Synodontismembranacea* Geoffroy Saint Hilaire from Jebba Lake, Nigeria. *Comp. Clin. Pathol.*, 20: 163-172.
- Stoskopf, M.K., 1993. *Clinical Pathology in Fish Medicine*. WB Saunders Company, New York, USA., Pp. 251.
- Summerfelt, R.C., Lewis, W.M. and Ulrich, M.G. 1967. Measurement of some hematological characteristics of the goldfish. *Progressive Fish Culturist* 29: 13-20

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Distribution of Individual Polybrominated Diphenyl Ethers (PBDEs) in Leachates from Electronic Waste (e-waste) Dumpsites in Two States of Southwest, Nigeria

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Abstract

The distribution of individual Polybrominated Diphenyl Ethers (PBDEs) of United States Environmental Protection Agency (USEPA) primary interest was investigated seasonally in raw leachates from e-waste dumpsites in Lagos and Osun States, South-west Nigeria for a period of 24 months (July 2012- July 2014). Physico-chemical parameters were measured using standard methods while the concentrations of PBDEs were determined using Gas Chromatography Electron Capture Detector (GC ECD). Turbidity, alkalinity and dissolved oxygen (DO) levels showed significant differences ($P \leq 0.05$) with the control in both states. This was attributed to high particulate matter content of the e-waste in the dumpsites. Generally higher concentrations of Σ PBDEs were recorded in Osun (25.80 $\mu\text{g/L}$) than in Lagos (1.10 $\mu\text{g/L}$) indicating the differences in the composition of the items in the waste streams. Dry season samples were found to be more enriched (16.2 $\mu\text{g/L}$) than the wet season (11.0 $\mu\text{g/L}$). The results from this present study showed the need to address the indiscriminate and uncontrolled dumping of e-wastes in developing countries considering the potential risks associated with the contamination of the aquatic food chain and subsequent human health implications.

Key words: E-waste, PBDEs, leachates, dumpsites, food chain

Introduction

Polybrominated Diphenyl Ethers (PBDEs) were the first brominated flame retardants (BFRs) to be detected in the environment (Dannon-Schaffer, 2010). They are a class of synthetic chemicals regarded as emerging contaminants many of which congeners are listed in the Stockholm Convention as persistent organic pollutants (Stockholm Convention, 2009). Their use as flame retardants for plastic components of electrical equipment have made e-waste a major source of PBDEs in the environment (Essumang *et al.*, 2018). Their highly toxic, persistent, bioaccumulative, endocrine-disrupting properties and the potential for long-range transport make them a major source of scientific concern. Nigeria is the highest generator of e-waste in West Africa while South-west Nigeria is the home of the two biggest sea ports which serve as major trade portals for e-waste not only to Nigeria but to the rest of West Africa (BAN 2002).

Contamination of the aquatic ecosystem by PBDEs has been shown to be majorly from plastics in electronic equipment discarded in landfills/dumpsites where they have the potential to leach into and contaminate the waterways through wastewater/leachates (Dannon-Schaffer, 2010; Essumang *et al.*, 2018). A recent study by Lui *et al.* (2015) demonstrated toxicities of aquatic organisms by these contaminants. Hence, they are of global concern. They affect the developmental processes of fish during the embryonic period, resulting in reduction of offspring quantity and quality (Dannon-Schaffer, 2010). It has been shown to negatively affect the nervous, endocrine and immune systems in humans through the contamination of the aquatic food chain (Lui *et al.*, 2015).

Based on the above background, this study was designed to determine the distribution patterns of individual PBDE congeners in leachates from e-waste dumpsites over a period of 24 months in Lagos and Osun States, Southwestern Nigeria

Materials and Methods

Study Area

South-West Nigeria lies between latitude $N09^{\circ}4'55.1964''$ and longitude $E08^{\circ}40'30.9972''$. The weather conditions vary between the two distinct seasons in the tropics: the rainy season (March – November) and the dry season (November to February). Sampling was performed quarterly (July 2012-July 2014) in the dumpsites located in Alaba (longitude $N06^{\circ}27'40.5''$ and latitude $E003^{\circ}11'32.4''$) and Ajegunle (longitude $N07^{\circ}46'51.5''$ and latitude $E004^{\circ}33'11.6''$) markets in Lagos and Osun states respectively (Figure 1).

Collection of Leachate Samples

Leachates samples were collected from 10 different points around the two dumpsites with a 1dm³ water sampler. The samples from each dumpsite were mixed to form composite samples and filtered using Whatman 10 mm IPS phase separator filter paper (Okunola *et al.*, 2012). They were stored in two different 1litre water bottles and transported to the laboratory for further analysis. The control was about 10 km away from each of the dumpsites where no history of electronic waste dissembling has been recorded.

The samples were analyzed for a number of standard physico-chemical properties using a Horiba-U-10 multi meter water checker and LaMotte spectrophotometer RMN26624.

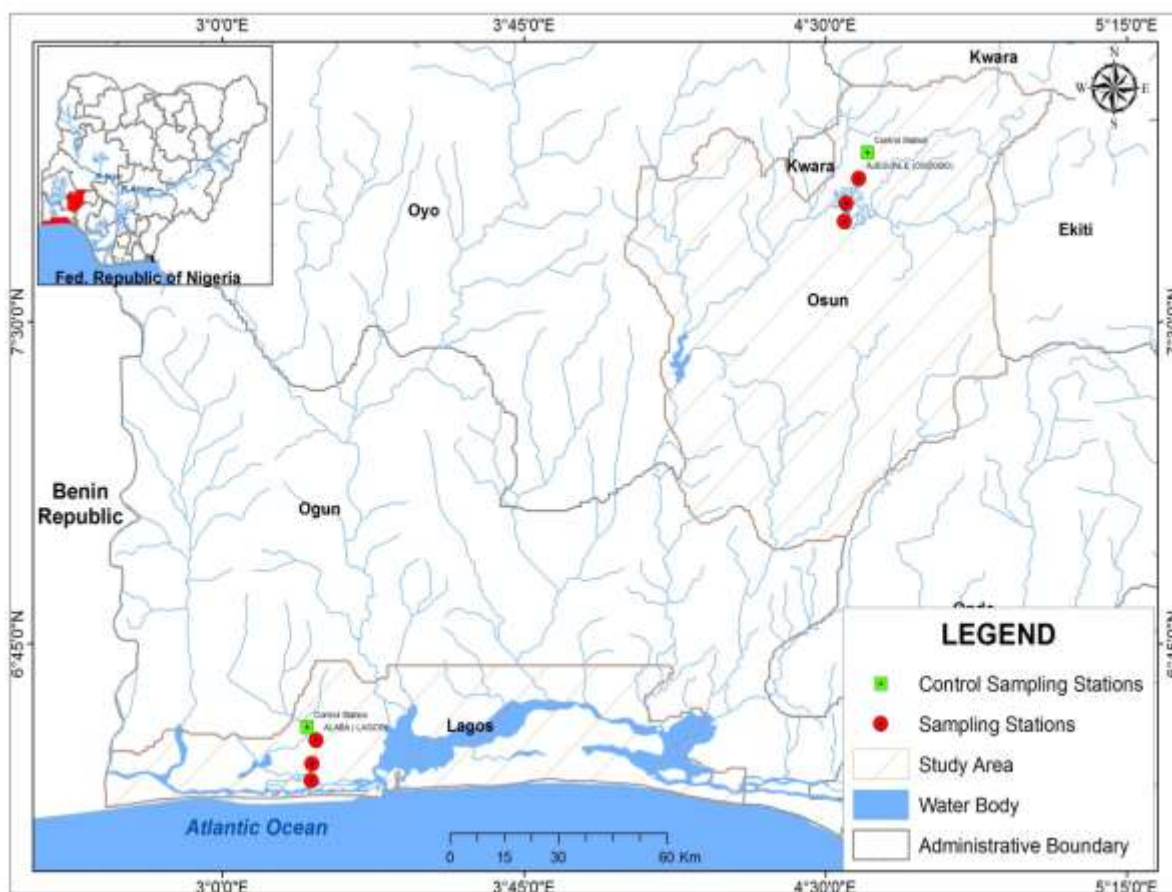


Figure 1: Map Showing Lagos and Osun Study Sites

Analysis of PBDEs

PBDE analysis was carried out according to the method of Yang *et al.* (2008). An internal standard was added to 50 mL of the sample leachate with 200 mL of hexane/dichloromethane (1:1, v/v) and the mixture was extracted using a separating funnel extraction (SFE). The concentrated extracts were cleaned on a 15-mm i.d. column and eluted with 70 mL of hexane: dichloromethane (1:1). The concentrations of 8 PBDE congeners were measured by GC-ECD Agilent 7820A. The recovery obtained for internal standard ranged from 82% to 98%.

Data Analysis

Descriptive statistics (mean values) were used and analysis of variance was performed on all experimental data and means were compared using SPSS version 20.0 software.

Results

The physicochemical parameters of leachate from e-wastes dumpsites in Lagos and Osun are presented in Table 1. Turbidity and dissolved oxygen levels were significantly different ($p < 0.05$) from the control in both states while alkalinity exceeded the USEPA (2009) limit.

Table 1: Physicochemical Parameters of Leachates (mg/L) in Lagos and Osun States

	Lagos			Osun			USEPA 2009)	NESREA (2009)
	Leachate	Control		Leachate	Control			
Physio-Chemical characteristics	Mean±SE	Mean±SE	t-stat.(p-value)	Mean±SE	Mean±SE	t-stat.(p-value)		
Air Temperature	27.25±0.56	26.38±1.46	0.286(0.776)	26.06±0.40	27.59±0.41	0.286(0.776)	n.a	n.a
Water Temperature	28.69±0.62	27.44±1.56	0.754(0.457)	25.69±2.00	27.76±0.54	0.754(0.457)	n.a	n.a
Salinity	0.52±0.20	0.42±0.20	0.414(0.682)	0.09±0.04	0.12±0.05	0.414(0.682)	n.a	n.a
pH	7.85±0.20	7.54±0.15	1.971(0.058)	8.05±0.22	7.73±0.08	1.971(0.058)	6.5 - 8.5	6 - 9
Conductivity	2.35±0.10	3.21±1.31	0.494(0.625)	1.21±0.22	1.19±0.15	0.494(0.625)	n.a	n.a
Turbidity	68.00±22.21	10.50±1.77	3.60*(0.001)	65.17±13.56	30.50±8.12	3.60*(0.001)	n.a	n.a
Alkalinity	92.13±10.95	10.56±0.72	4.304*(0.000)	92.00±20.25	22.13±5.91	4.304*(0.000)	20	150
Dissolved Oxygen	1.96±1.37	6.78±1.35	1.78*(0.085)	2.82±1.80	4.75±0.94	1.78*(0.085)	n.a	n.a
BOD	1.85±0.55	0.55±0.14	1.65(0.110)	1.45±0.32	0.21±0.17	1.65(0.110)	250	50
Silicate	59.000±5.19	0.51±0.23	5.58(0.00)	23.67±2.69	11.76±3.42	5.58(0.00)	n.a	n.a
Nitrate	1.84±0.65	0.11±0.05	2.26(0.031)	0.64±0.36	0.47±0.14	2.26(0.031)	10	10
Phosphate	20.11±4.24	0.15±0.08	0.461(0.648)	20.03±2.82	5.19±2.61	0.461(0.648)	5	2
Sulphate	28.13±10.73	0.08±0.02	4.11*(0.00)	17.00±6.00	38.16±12.12	4.11*(0.00)	n.a	n.a

* Significant level at $p < 0.05$. n.a: data not available. Units are in mg/L except conductivity ($\mu\text{S}/\text{cm}$), salinity (ppm) Temperature ($^{\circ}\text{C}$) and PH which has no unit. BOD-biological oxygen demand, NESREA- National Environmental Standards Regulation and Enforcement Agency.

Concentrations of Individual PBDEs in leachates ($\mu\text{g}/\text{L}$) from Lagos and Osun States

Higher concentrations of total PBDEs were recorded in Osun than in Lagos (Table 2). Out of the eight congeners screened, only BDE99 and BDE 183 with concentrations of 0.50 $\mu\text{g}/\text{L}$ and 0.70 $\mu\text{g}/\text{L}$ were detected in Lagos sample while Osun leachate was enriched with seven congeners namely BDE 28 (4.00 $\mu\text{g}/\text{L}$), BDE 99 (3.6 $\mu\text{g}/\text{L}$), BDE 100 (0.8 $\mu\text{g}/\text{L}$), BDE 153 (1.40 $\mu\text{g}/\text{L}$), BDE 154 (6.40 $\mu\text{g}/\text{L}$) and BDE 183 (8.30 $\mu\text{g}/\text{L}$).

Table 2: Concentrations of PBDEs in Leachates from Lagos and Osun States

Congeners	Lagos	Osun
BDE 28	ND	4.00
Σ tri-BDE	ND	4.00
BDE 47	ND	0.60
Σ tetra-BDE	ND	0.60
BDE 99	0.50	3.60
BDE 100	ND	0.80
Σ penta-BDE	0.50	4.40
BDE 153	ND	1.40
BDE 154	ND	6.40
Σ hexa-BDE	ND	7.80
BDE 183	0.70	8.30
Σ hepta-BDE	0.70	8.30
BDE 209	ND	ND
Σ deca-BDE	ND	ND
Σ -PBDEs	1.2	25.1

ND= not detected

Seasonal Distribution Patterns of PBDE Congeners in the Leachate ($\mu\text{g/L}$) from Lagos and Osun States

Relatively higher levels of congeners occurred in the dry than in the wet season. A total of 15.3 $\mu\text{g/L}$ and 10.5 $\mu\text{g/L}$ were recorded in Osun while 0.70 $\mu\text{g/L}$ and 0.20 $\mu\text{g/L}$ were recorded in Lagos during the dry and wet seasons respectively (Figure 2).

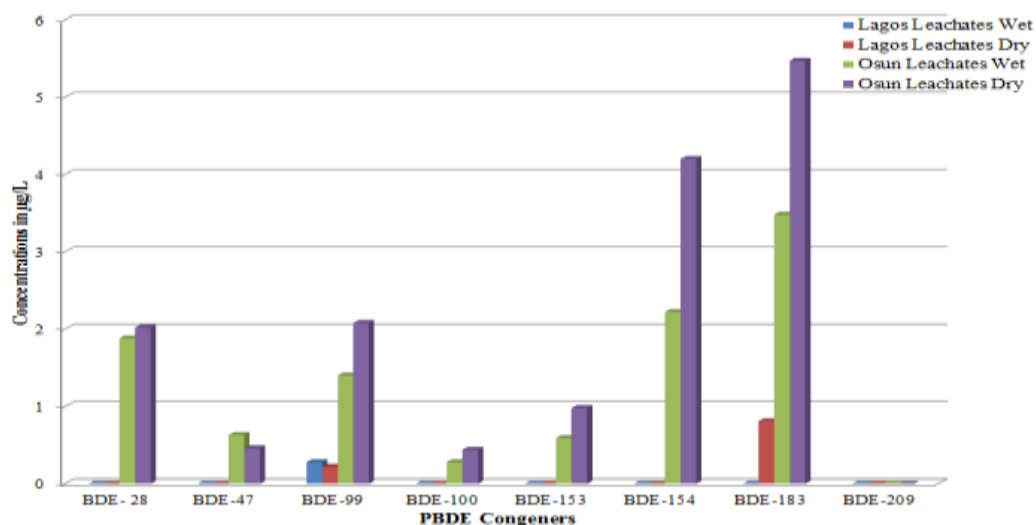


Figure 2: Distribution of individual PBDE congeners in leachate samples from Lagos and Osun states-e-waste dumpsites in the wet and dry season.

Discussion

The leaching of PBDEs from electronic waste have been documented in some literatures (Essumang *et al.*, 2018 and Dannon-shaffer, 2010.). The high turbidity in the leachates from both states was attributed to high levels of particulate matter from the dumpsites. This is in agreement with an earlier study (Lui *et al.*, 2015). The absence of congener 209 (deca BDE) in the leachate samples is an indication of its ability to undergo photo-transformation to reductive debromination in organic solvents. This results in the formation of lower brominated BDEs (Ikonomou *et al.*, 2002). A similar result was recorded by Dannon-Shaffer (2010). The presence of Congener BDE 99 (Penta BDE) in the samples from both states confirms it is the most persistent and toxic of all the congeners (de Wit *et al.*, 2016). A report by Okunola *et al.*, (2012) mentioned that it is a highly toxic, persistent, endocrine-disrupting chemical with potential for long-range transport and ability to leach and bioaccumulate in biota including fish. PBDEs have also been detected in human adipose tissues, human blood (Lui *et al.*, 2015) and breast milk (de Wit *et al.*, 2016). Thus, the rising concentrations of PBDEs in the environment is of ecological and human health risks due to their dioxin-like properties (Essumang *et al.*, 2018).

Conclusion

This study revealed the presence of PBDE congeners in e-waste leachates. This could impact on the development of exposed aquatic organisms as well as have detrimental effects on the surrounding environments. Concluding therefore, the problem of indiscriminate and illegal dumping of e-waste should be addressed urgently in Nigeria as contaminated organisms from this environment could pose as important exposure pathways for humans, leading to potential health consequences.

References

- Dannon-Schaffer. M. (2010). Polybrominated diphenyl ethers in landfills from electronic wastes. Ph.D Thesis, University of British Columbia, Vancouver, 442pp.
- De Wit, C; Alace, M and Muir D.C.G (2006). Levels and trends of Brominated Flame Retardants in the Arctic. *Chemosphere*, **64**: 209-233.
- Essumang, D.K., Adjei, J.K., Cann, S.K., Essel, G and Osei, F.P (2018). Levels of PBDEs in some Ghanaian Water Body Environment. *Res. J. of Environ Sci.* **12** (2) 73 – 82
- Lui, H., Tang, S, Zheng, X, Zhu, Y, Ma, Z (2015) Bioaccumulation, Biotransformation and Toxicity of BDE 47 in Early Life Stages of Zebra Fish (*Danio rerio*) *Environ, Sci, Technol.* **49** (3) 1823 - 1833

- Ikonomou, M. G., Rayne, S and Addison, R. F. (2002). Exponential increases of the Brominated Flame Retardants, Polybrominated Diphenyl Ethers, in the Canadian Arctic from 1981 to 2000. *Environ. Sci. and Technol.* **36**:1886-1892.
- Okunola, A.A., Bakare, A. A., Xijun Ka, Bin Li, Yuling Zhang and Xia Huo (2012). Comparative evaluation of environmental contamination and DNA damage induced by electronic wastes in Nigeria and China. *Science of the Total Environment*, **423**: 62 – 72.
- Yang, Z. Z., Zhao, X. R., Zhao, Q., Qin, X. F., Xu, X. B., Jin, Z. X. and Xu, C. X. (2008). Polybrominated diphenyl ethers in leaves and soil from typical electronics waste polluted area in South China. *Bull. Environ Contamination Toxicol* **80**:340-344.

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Overview of Niger Delta Coastal Environment and Fisheries Resources

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The Niger Delta is located at the southern section of Nigeria, which includes nine states of the federation and is bordered by the Atlantic Ocean. The naturally endowed Niger Delta region is rich in a wide diversity of fisheries resources whose potential for economic growth of the region are majorly untapped and underutilized. The aquatic habitats provide essential services to many households in the region, in addition to being a dependable source of food and income. Unfortunately, however, anthropogenic activities and the snowballing effects of climate change seem to be impacting negatively on the rich biodiversity of the aquatic resources in the region. Fishermen/fisherwomen are faced with the crisis of dwindling catches which have been attributed to many factors particularly overfishing and environmental degradation caused by pollution. The degrading activities must be checked so that sustainable fisheries production and other benefits from a Delta can be considerably reaped for the benefits of the Nigerian populace.

Keywords: coastal ecosystem, environmental degradation, fisheries resources, Niger Delta

Introduction

The Niger Delta area is the southernmost region of Nigeria. Although it occupies 90% of the Nigerian coastline, it is specifically between the Mahin river estuary in the west and the Cross river estuary in the east (Enemugwem, 2010). Ogbe, 2005 reported that the Niger Delta Coastal Environment is endowed with abundant natural resources, species biomass and biodiversity and it is the area with the most abundant fresh water species in West Africa. A geographical area measuring over 70,000 square kilometer with a population of over 31 million inhabitants, it is broadly viewed to comprise about 16,000 communities in the nine (9) oil producing states of Abia, Akwa Ibom, Bayelsa, Cross Rivers, Delta, Edo, Imo, Ondo and Rivers; with over 40 different ethnic groups who speak more than 250 languages and dialects (Amaechi, 2009). The Niger Delta is the third largest wetland in the world and boasts of the 4th largest mangrove area (Stewart, 2006). Studies from Mmon and Chukwu-Okeah, 2011; Emuedoet *et al.*, 2014 also reported that: the mangrove swamps, the fourth largest in the world is predominant, basically consisting of Red mangroves (*Rhizophora racemosa*), *R. harrisonii* and *R. mangle* which are the most abundant mangrove species, the other two less abundant mangrove species are the *Avicennia germinans* and *Languncularia racemosa*. The delta is described as the home of extraordinary biodiversity, and is also endowed with several mineral deposits. The Niger Delta covers approximately 35% of all West African mangroves (Zabbey and Tanee, 2016). Wetlands are continuously flooded, which supports the vast vegetation, diverse flora and fauna and sediments which are the habitat to hundreds of aquatic organisms. Mangroves provide many services to support the livelihood such as firewood, wood for building and construction companies, honey, dye-binding, furniture, traditional medicine amongst others (Zabbey and Tanee, 2016). The economic activities in the coastal environment are oil and gas exploration and exploitation, various shipping and fishing industries, agricultural activities and also the aesthetic features of the area, which promotes the tourism sector of the economy (Mmon and Chukwu-Okeah, 2011). The region has huge oil and gas reservoirs (World Bank, 2008), ranking as the 6th world's largest exporter of crude oil and 3rd world largest producers of palm oil after Malaysia and Indonesia (Omofonmwan & Odia, 2009). For many decades, the 63 region has remained the backbone of the Nigerian economy, accounting for over 90% of the country's foreign exchange revenue (Niger Delta Regional Development Master Plan, 2006).

The Delta's environment can be broken down into four distinct ecological zones. Coastal barrier Islands; Mangrove swamp forests; Freshwater swamps and Rainforests (Mmon and Chukwu-Okeah, 2011)

The composite of Niger Delta states accounts for 25% of the country's total population (Mmon and Chukwu-Okeah, 2011). Presently, oil exploration and exploitation accounts for over 80% of state revenues, 90% of foreign exchange earnings and 96% of oil export revenues (Ohiorhenan 1984; Ikelegbe 2005; UNSD, 2009). Other activities carried out within this region are oil refining, fishing, agricultural activities, sand mining and fertilizer production.

Fisheries Resources of the Niger Delta

Fisheries particularly the small scale type characterized by the use of low technology fishing gear over a limited range, are fundamentally important in many regions of the world, providing important sources of protein and livelihoods for coastal and rural communities (FAO, 2004). Fish base (2010) described Nigeria a coastal state with huge fishery resources both in marine and inland waters with about 800 known species. The dermesal target species exploited by artisanal fishing units are : croakers (*Pseudotolithus*), thread fins (*Galeoides*, *Pentanemus* and *Polydactylus*), soles (*Cynoglossidae*), marine catfish (*Arius*), the snappers (*Lutjanidae*), rays (*Trygonidae*), skates (*Rajidae*), sea bream (*Sparidae*) and shrimps (*Penaeidae*). The rivers forming the Niger delta that is the River Niger and River Benue, and their tributaries, natural lakes, other wetlands and reservoirs all constitute the total water area in Nigeria. It has been estimated that 35% of animal protein consumed in Nigeria come from fish, and the contribution from the Niger Delta being over 35% of the fish supply. However, despite its huge water resources, fish production is declining, resulting in 800,000 MT total consumption (FBS, Nigeria, 2007). This has been attributed to insecurity along the country's coasts and waterways, higher energy costs than before, overfishing, poaching, degradation of fish habitats and coastal environment, poor roads and improper market infrastructure.

Marine Fishes

Francis *et al.* 2004, reported that our coastal zone is home to some 104 species of fish belonging to 50 families. Some of the species of commercial importance include: Croaker, *Pseudotolithus typus*, *P. senegalensis*, *P. elongatus*; soles, *Cynoglossus spp*; Shinnose, *Polydactylus quadrifilis*; Sea catfish, *Arius spp*; Grouper, *Epinephelus spp*; large tarpons, *Megalops atlantica* and various sparids (breams). Other commercially important species include: moonfishes, *Vomer setapinnis*; *Trichiurus lepturus*; Jack fish, *Carranx spp* and Bigeye, *Brachydeuterus auritus*.

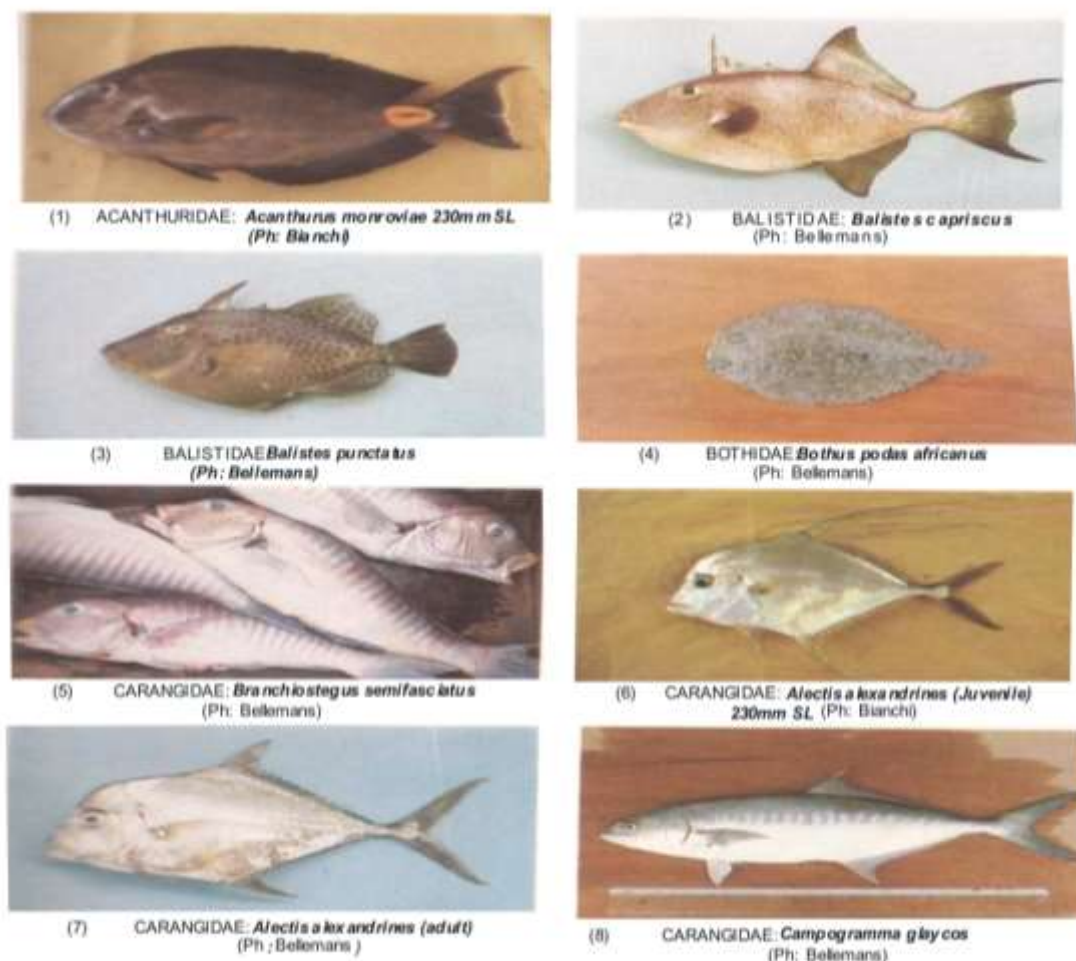


Plate 2: Representative of marine fishes (source : Sikokoet *al.*, 2013)

Freshwater Fishes

Commercially important freshwater fish families in Nigerian waters include the mormyridae (43 species); Cyprinidae (32); Mochokidae (27); characidae (25) and Cichlidae (19). However, the catfishes appear to be more commercially important. In all some 196 species belonging to 105 genera representing 46 families have been recovered in the freshwater sector (Leveque *et al.*, 1991).

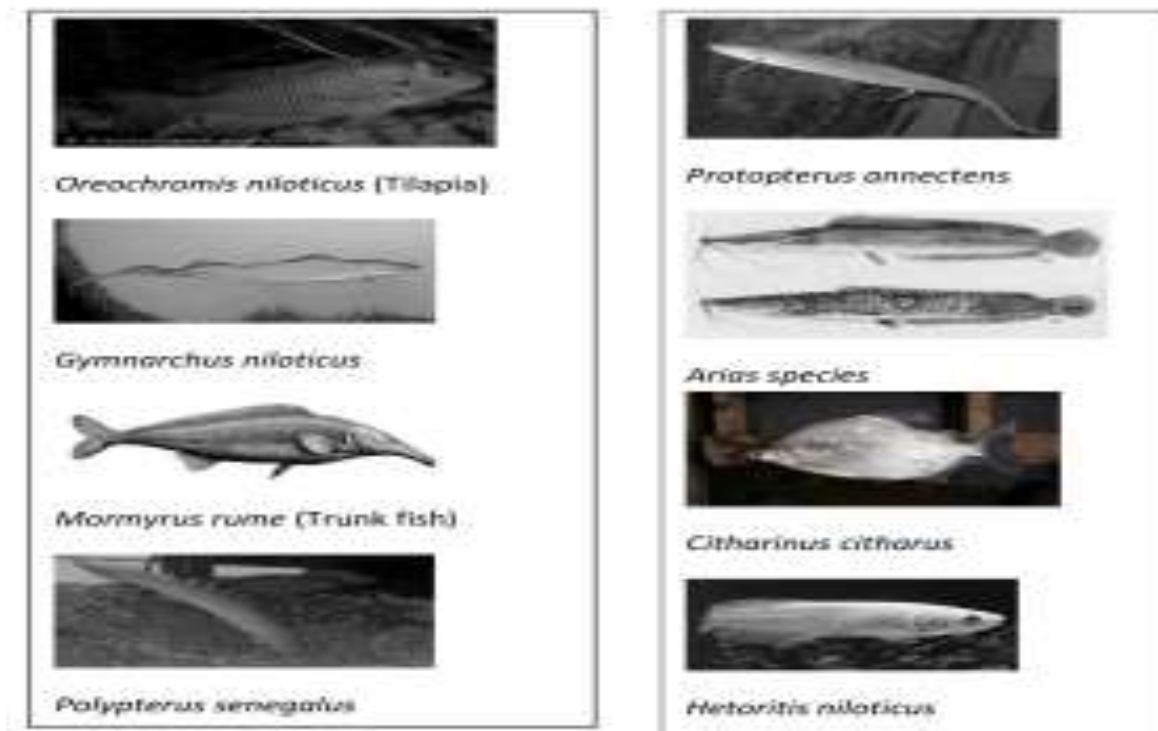


Plate 3: Representative of fresh water species of the Niger Delta (Sikokoet *et al.*, 2013)

Shell fishes

Shellfish is a culinary and fisheries term for exoskeleton-bearing aquatic invertebrates mostly used as food. They include various species of molluscs, crustaceans, and echinoderms. Taxonomically, shellfishes belong to the phylum Arthropoda and phylum Mollusca. Familiar marine molluscs used as food source by humans include many species of clams, mussels, oysters, wrinkles and scallops. Some crustaceans such as shrimps, prawns, lobsters, crayfish, and crabs are a feature of almost all the cuisines in the world. Echinoderms are not as frequently harvested for food as molluscs and crustaceans, but sea urchin is quite popular in many parts of the world. Although their shells may differ, all shellfish are invertebrates (Jimoh and Lemomu, 2010).

Nigeria has a wide variety of shellfish resources ranging from the molluscs such as ark clams (*Senila senilis*), cockles (*Cardium costatum*), periwinkle (*Tympanotonus fuscatus*) to the crustaceans which includes the penaeidae (shrimps), palaemonidae (prawns), portunidae (swimming crabs) and palinuridae (lobsters). Estimated potential yield for shellfishes is 51,760 metric tonnes. Shrimps and prawns have the highest commercial importance with production estimate between 10,000 to 15,000mt. More than half of this figure is exported to the Organization for Economic Co-operation and Development (OECD) countries with shrimp market valued at US \$8.6 billion. Nigeria generated about US \$54million in 2005 from export of shrimps and prawns alone. This figure decreased to about US \$38million in 2007 due to harassment by sea pirates and militant groups thus decreasing production from 13,767mt in 2006 to an alarming 5,995mt in 2007. However more research needs to be done to ascertain the true potential yield and environmental carrying capacity of the Nigerian shellfisheries to determine the maximum sustainable yield (MSY) so as to prevent over exploitation and consequently the destruction of the fishery. Research should also be carried out on other shellfish resources such as crabs, oysters, periwinkles and lobsters as appreciable income could be earned from their sales and export (Jimoh and Lemomu, 2010).

Commercial Importance of Nigerian Shellfish Resources

The economy of any nation is dependent on the careful use of human resource: money, time, strength and the operation of a country's money supply, industry and trade. There are several sectors contributing adequately to the Nigerian economy. Notable amongst which are the agricultural, oil and gas, banking and finance, textile, information technology and transportation sectors. Although oil and gas is the back bone of the Nigerian economy as it provides 95% of foreign exchange earnings and about 65% of budgetary revenues, the agriculture sector however is the largest non-oil sector of the Nigerian economy as it contributes about 88% of the non-oil foreign exchange earnings and employs about 70% of the active labour force of the population. Nigeria earns appreciable foreign exchange from exportation of shell fisheries products such as shrimps, prawns, crabs and crab claws. Shrimp has grown into a significant global seafood industry, producing nearly four million tonnes worth about \$18 billion annually. Approximately half of the global shrimp supply is traded internationally, with trade flowing mainly from the tropical developing world to the OECD (Organization for Economic Cooperation and Development) countries. Shrimp imports by these wealthy markets reached \$7.8 billion in 2001. Combined with the domestic production in the USA and Europe, the total OECD market is valued at \$8.6billion. Nigeria generated about US \$54million in 2005 on export of shrimps and prawns alone. The amount generated from the shrimp and prawn decreased to about US \$38million in 2007 due to harassment by sea pirates and militant groups thus decreasing production from 13,767mt in 2006 to an alarming 5,995mt in 2007(Jimoh and Lemomu,2010).

Table 1: Nigerian Shellfish Production by Species in metric tonnes (1995 – 2007)

FAO ENGLISH NAME	SCIENTIFIC NAME	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Marine crab	Brachyura (Callinectes)	48	1473	593	3384	4017	3211	4415	5029	4218	3694	3688	6990	1963
Spiny lobsters	Pallinurus sp.	1496	1133	8315	471	1378	1939	1754	193	1904	1943	2456	2921	1610
Shrimp	Penaeus notialis	14742	12073	14799	19761	10941	11067	15035	13413	13301	11410	12397	11928	10852
Prawn	Pandalidae	N/A	N/A	N/A	N/A	16458	7815	9691	15581	13335	9846	14540	17354	9475
Crayfish	Notantia	4474	3417	3456	2600	2690	1564	909	1495	1669	1659	1611	4939	1943
Periwinkle	Littorina sp.	N/A	N/A	N/A	2357	2612	2345	2084	2426	2741	2913	2822	2475	2866
Total		20760	18096	27163	28573	38096	27941	33906	38137	37068	31465	37514	43587	28709

Source: Federal Department of Fisheries, FDF (2007)



Prawn



Crab



cockle

Representative of shell fishes (Source:Google.com)

Challenges Of Maintaining The Health Of Fisheries Resources In The Niger Delta

The naturally endowed Delta environment in Nigeria is of great potential and cannot be overlooked. The degrading activities have to be checked so that sustainable fisheries production and other benefits from a Delta can be greatly harvested in Nigeria. The aquatic environment is a very important resource and must be maintained to provide all essential services now and in the future. Coastal states of Nigeria have issues bordering on waste management difficulties and a direct consequence of congestion arising from population drift to the coastal areas. The more people in an area, the higher the waste generated; this Niger Delta region is not an exception to these notions. In addition excess runoff water drained from up country head for the Atlantic Ocean, thereby rendering the coastal environment prone to flood. Parts of the coastal areas are also endowed with crude oil deposits; exploitation of this natural resource and degradation of the environment have left many residents of these areas impoverished.

Recommendation and Conclusion

Government should re-equip the existing Agencies such as the Licensing, monitoring and Enforcement unit of Federal and State Departments of Environment and Fisheries to enable them implement and enforce conservation policies and regulations effectively. Sustainability of fisheries resources and coastal ecosystems depends on collaboration by all stakeholders to introduce adjustments to industrial processes, oil spill prevention, response preparedness; restoration framework and implementation plan. Corporate Social Responsibility (CSR) and Environmental Stewardship should be required of the oil exploitation industries and enforced by the federal government (Olanikeet *et al.*, 2017). The generation of waste and proper disposal, and the health and economic effect resulting from the inadequate waste disposal should be addressed at all levels if any reduction in waste products, proper disposal and societal obligations are to take foothold. There is the need to involve all stakeholders. Remember that all unsustainable and unfriendly environmental practices by humans create "irreversible" imbalances and environmental pollution. Fisheries management which aims at producing sustainable benefits in a fishery; benefits emanating from the biological, social and economic dimensions of the fisheries resources (Francis *et al.*, 2016) should be effected in our ecosystem following different decrees and management approaches which have been developed to act as a guide for the management of the fisheries resource and these include: Ecosystem Based Fisheries Management approach, Precautionary principle, Co-management, Community based management, technical measure as well as user right measures. The principles in some of these measures or approaches are normally combined to form an effective strategy that will make either for recovery, conservation and sustainable exploitation and utilization. Most nations of the world are reviewing their fishery policy and the regulating instrument such as a Fisheries Act or Law so that ecologically sustainable approaches enshrined into the code of Conduct for Responsible Fisheries and other instruments can be introduced into the fisheries policy. The Nigerian Government should ensure that her decrees for example the No.10 decree of the 1992 Inland fisheries act be reviewed and enforced as the law by nature of the year is out dated and need to be reviewed and acted upon.

References

- Adaba T. Ibim and Lilian C. Njoku (2018). Fish Assemblage of Amadi Creek, Port Harcourt, Rivers state Nigeria. *American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)*. Volume 39, No 1, pp 180-196
- Adeyemo O.K, (2003): Consequences of Pollution and Degradation of Nigerian Aquatic Environment on Fisheries Resources. *Environmentalist*, 23(4): 297-306.
- Adeyemo O.K. (2008): Habitat assessment for seasonal variation of River pollution in Ibadan, Nigeria, in a geographic information systems interface. *Veterinaria Italiana*, 44 (2), 361-371.
- Akaninwor J.O Anosike E.O and Egwin, O (2007). Effect of Indomie Industrial effluent discharge on microbial properties of New Calabar River. *Scientific and Research Essay*. 2 (1) : 001-005 .
- Akankali, J.A, Davies I.C and Nwafili, S.A(2018):Metal Concentration in Grey Mulletts (*Mugil cephalus*)and New Calabar River ,Iwofe , Niger Delta of Nigeria. *Nigerian Journal of Fisheries and Aquaculture* 6 (2):43-50.
- Aluko, M.A.O (2004) Sustainable Development, Environmental Degradation and the Entrenchment of Poverty in Niger Delta area of Nigeria. *Journal of Human Ecology* 15 (1) 63-68.
- Burke, L., Y. Kura, K. Kassem, C. Ravenga, M. Spalding, and D. McAllister, (2001): Pilot Assessment of Global Ecosystems: Coastal Ecosystems. World Resources Institute (WRI), Washington, D.C. (USA), 94 pp.
- Carter, R.W.G. and Woodroffe, C.D., editors, 1994: Coastal evolution. Cambridge University Press. xxii + 524 pp.
- Cowell, P.J. and B.G. Thorn.(1994).Morphodynamics of coastal Cambridge University press. pp 33-86.
- Costanza, R., R. d'Arge, R. deGroot, S. Farber, M.Grasso, *et al.* (1997): The value of the world's ecosystem services and natural capital. *Nature*, 387(6630), 253–260.
- Dienye, H. E., O. A. Olopade and S. A. Toby (2018). Species Composition And Diversity Of Cast Net Fisheries in New Calabar River, Niger Delta, Nigeria) *J. Biodivers. Conserv. Bioresour. Manag.* 4(1), 2018.
- Elenwo E.I.&Akankali J.A (2015) : Sources of Marine Pollution on Nigerian Coastal Resources: An Overview. *Open Journal of Marine Science* 05(02): 226-236.
- Francis A. and Sikoki, F.D., 2004 b. Fishes of the Andoni River system brackish waters – Niger Delta, Nigeria. *Afri J. Interdisciplinary Studies*. 5(1) 123-130.
- Francis A.andSikoko F.D(2016).Fisheries Resources: Sustainable exploitation and Contribution to the Nigerian Economy.ISBN:978-978-54287-2-8.
- Hiborn and Ray (2007).''Managing fisheries is managing people: What has been learned/''.*Fish and Fisheries* 8(4):285-296.
- Idodo-Umeh, G. (2002): Pollution assessments of Olomoro Water bodies using Physical, Chemical and Biological indices: PhD. Thesis, University of Benin, Benin City, Nigeria, p. 485.

- Jack IR, Fekarurhobo GK, Igwe FU (2005). Determination of hydrocarbon levels in some marine organisms from some towns within the Rivers State of Nigeria. *J. Appl. Sci. Environ. Manage.* 9:59-61.
- Jimoh, A.A. and Lemomu, I.P.(2010):Shell Fish Resources In Nigeria. Proceedings Of Fisheries Society Of Nigeria (FISON) ASCON, BADAGRY 25th-29th OCTOBER 2010. ISSN: 1117-3149
- Jimmy o. Adegoke, *Journal of sustainable development* vol.3, No.4; December 2010.
- Kadafa, A.A (2012): Oil Exploration and Spillage in The Niger Delta of Nigeria. *Civil & Engineering Research* 2(3) 38-51
- Kuruk, P. (2004): Costomary Water Laws and Practices: Nigeria. <http://www.fao.org/legal/adverv/FOA/UCNCS.Nigeria.pdf>.
- Moffat, D. and Olof, L. (1995): Perception and Reality: Assessing Priorities for Sustainable Development in the Niger River Delta. *Ambio* Vol. 24. 7/8December PP. 527-538.
- Iniaghe P.O, Godswill O.T and Iniaghe O.P (2013): Environmental degradation and Sustainable Development in Nigeria's Niger Delta region. *Journal of Sustainable Development in Africa* 15, (3):112-123.
- Wilson Shaun and Barry Shaun (2019): World Seas: an Environmental Evaluation (Second Edition) Volume II: the Indian Ocean to the Pacific. Chapter 14: The North-Western Margin of Australia , Pages303-331.
- NenibariniZabbey and Franklin B.G.Tanee (2016): Assessment of Asymmetric Mangrove Restoration Trials in Ogoniland, Niger Delta, Nigeria: Lessons for the future. *Ecological restoration* 34:3-14.
- Adeyemo O.K, Ubiogoro O.E and Adedeji O.B (2017) :Oil exploration, Fisheries resources and Sustainable livelihood in the Niger Delta, Nigeria. *Nature and Fauna* 24 (1): 1-60.
- Onuoha G.C.(2009).Fundamental Principles of Fisheries Science. New Edition Digital Press, Umuahia. Pp.164.
- Pauly and Daniel (2007). 'The Sea around us Project: Documenting and Communicating Global Fisheries Impacts on Marine Ecosystems'. *AMBIO:A Journal of the Human Environment*.36(4):290-295.
- Pidwirny, M. (2006 a).Fundamentals of physical geography. Chapter 10:Introduction to the lithosphere: Coastal and marine processes and landforms. University of British Columbia; Okanagan.(online) available : <http://www.physicalgeography.net/fundamentals/10ac.html>.Assessed:march,2007.
- Pidwirny M. (2006b). Fundamentals of physical geography. Chapter 10: Introduction to the Lithosphere: Erosion and deposition. University of British Columbia, Okanagan.
- Solomon, L., Okorite George-West, O. and Alalibo, I.K (2017).Environmental Pollution in Niger Delta and Consequential Challenges to Sustainable Development of the Region: the Role of an Individual. Vol. 9 (8):10-15 ISSN 1553-9865(PRINT); ISSN 2163-8950(online). <http://www.sciencepub.net/researcher.3.d0i:10.7537/marsrj090817,03>
- Spalding, M., Blasco, F. and Field, C. (Eds.) (1997): World mangrove atlas. The International Society for Mangrove Ecosystems, Okinawa, Japan. 178pp.
- Stewart, N.F. (2006) Deprivation, Environmental Degradation and Armed Conflicts: Need for Sustainable Development of Niger Delta Wetlands. Department of Public law, University of Benin, Benin City.
- Wilson, R.I., Turner, G.C., Laurent, G.(2004).Transformation of olfactory representations in the *Drosophila* antennal lobe. *Science* 303(5656): 366-370.
- World Bank (1995): Defining an Environmental Strategy for the Niger Delta.
- United Nations Environment Programme Global Environment Monitoring System/Water Programme. (UNEP-GEMS/WP) (2000).Water Quality for Ecosystem and Human Health. National Water Research Institute. Burlington:

FISH NUTRITION, PROCESSING AND PRODUCT DEVELOPMENT

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Effects of Replacement of Soya Bean (*Glycine Max. Linn*) Meal with Soya Bean Offal Meal on the Growth Performance of *Oreochromis niloticus* (Linnaeus, 1758)

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Abstract

The study was conducted to investigate the effect of replacing soya bean meal with soya bean offal meal in the diet of the Nile tilapia, *O. niloticus* fingerlings and to determine its growth performance. Fifteen (15) plastic rearing tanks (30cm x 45cm x 35cm depth) were used for the experiment. Plastic rearing tanks were randomly assigned in three replicates to five treatments. Three hundred (300) fingerlings of *O. niloticus* of mixed sexes and sizes of initial mean weight of (6.0±2.04^a g) were stocked in fifteen (15) white rectangular plastic tanks. Soya bean Offal meal (SBOFFM) was used to replace Soya bean meal (SBM) at inclusion levels of 0%, 25%, 50%, 75% and 100% for Diet 1 to 5 respectively. T1- 24.82±0.72^b CP, T2- 25.34±1.93^a CP, T3- 24.75±1.01^b CP, T4- 24.21± 0.43^b CP and T5- 25.12±0.70^a CP. Total growing period was 97 days (14 days of acclimatization and 83 days of feeding). The results obtained showed T2 (25.34±1.93^a) (25%) inclusion Soya bean Offal had the highest Mean Weight Gain (MWG) of (21.97±4.29^a g), Mean Length Gain (MLG) of (1.76±0.23^a cm), Protein Efficiency Ratio (PER) of 0.867±0.5^a g, Net Protein Utilization (NPU) of 150.35± 0.2^a %, Feed Efficiency Ratio (FER) of 1.89±0.4^a, Gross Feed Conversion Efficiency (GFCE) of 200.00±0.4^a and crude protein of *O. niloticus* carcass (38.1±0.20^a g/100g DM). Feed Conversion Ratio (FCR) and Specific Growth Rate showed no significant difference (P≥0.05).. The study results demonstrate that soya bean offal meal could replace the soya bean meal in the diet of Nile tilapia without negative effects on growth, or on total production and even leading to high net economic returns as shown in the diets with 25% CP crude protein from plant sources.

Keywords: Growth performance, Cost effectiveness, Soyabean Offal, *Oreochromis niloticus*, Fingerlings

Introduction

As aquaculture production becomes more intensive in Nigeria, fish feed could be a significant factor in increasing productivity and profitability as it accounts for at least 60 percent of the cost of fish production (Jamiu and Ayinla, 2003). The need to intensify the culture of the fish, so as to meet the ever increasing demand has made it essential to develop suitable diets either in supplementary forms for ponds or as complete feed in tanks (Olukunle, 2006). For the purpose of nutritional and economic benefits, previous researchers have made attempts at increasing the use of non-conventional plant and animal materials to replace conventional feed ingredients like maize and fish meal in fish feed ration. Nigeria is the second largest producer of farm-raised tilapia in Africa, after Egypt (Fagbenro *et al.*, 2010), however, her contribution to global output is just a meager 28,950 metric tons. The members of the genus *Oreochromis* are all herbivorous, feeding on algae, aquatic plants, and other detrital materials (Agbo *et al.*, 2015). Supplemental diets are usually less expensive than complete diets and are high in carbohydrates which aids productivity (Abu *et al.*, 2010). Tilapia exhibit their best growth rates when they are fed a balanced diet that provides a proper mixture of protein, carbohydrates, lipids, vitamins, mineral and fibre. Kromeet *et al.* (2016) provided excellent reviews that examined the details of tilapia nutrition.

The nutritional requirements are slightly different for each species and more importantly vary with the different life stages. Fry and fingerlings require a diet higher in protein, lipids, vitamins and minerals and lower in carbohydrates as they are developing muscle, internal organs and bone with rapid growth. Sub-adult fish need more calories from fat and carbohydrates for basal metabolism and a smaller percentage of protein for growth. Adult fish need even less protein, however the amino acids that make up that protein need to be available in the diet (Agbo *et al.*, 2015). Corn, wheat, rice and a number of agricultural products are typical carbohydrate sources (Agbo *et al.*, 2015). The ratio of energy, lipids and carbohydrates to the proteins available in the diet are often critical measures. Ng and Romano (2013) provided a comprehensive review of carbohydrate and fiber utilization in tilapia. Vitamins and minerals are critical to proper nutrition in tilapia and considerable research has been conducted to determine these requirements (Agbo *et al.*, 2015). Specific nutritional needs vary with species, age of fish, production system, and salinity. According to FAO (2006), catches from capture fisheries alone cannot meet the growing global demand for fish resources. There is need for a viable alternative fish production system that can sufficiently meet this demand, and

aquaculture fits exactly into this role (Abu *et al.*, 2010). Precocious breeding and high cost of feed are among the militating factors to tilapia production. Although, there has been breakthrough in checking the precocious breeding of tilapia through genetically modified parent stock and administration of Methyl-testosterone (MT) feed, availability of cost effective and highly potent feed still remains a major constraint to tilapia culture in Nigeria. Materials and Methods

Materials and Methods

Experimental site and Fish

The experiment was conducted at the Fisheries Laboratory, Department of Biology, Ahmadu Bello University Zaria, Nigeria. Three hundred (300) *Oreochromis niloticus* fingerlings of initial mean weight of (6.0±2.04g) were used in the experiment and were obtained from Fagam fish farm, Mariri Ward, Kumbotso Local Government Area, Kano State.

Experimental Set-up

Fifteen plastic rearing tanks of 30cm x 45cm x 35cm depth were used for the experiment set horizontally with each having an outlet separately. Five treatment diets were used in the experiment with the first treatment as a control. Each treatment has two replicates, twenty (20) fingerlings of *O. niloticus* were stocked per tank according to Ofor (2007). The tanks were covered with net meshes to prevent fish from jumping out. A partial flow-through system with fresh dechlorinated water was used throughout the experiment.

Feed Formulation

Five diets of varying proteins replacement were formulated at 100% soya bean meal (31.7g), 0% soya bean offal meal, 75% soya bean meal (23.77g), 25% soya bean offal (7.93g), 50% soya bean meal (15.85g), 50% soya bean offal meal (13.55g), 25% soya bean meal (7.93g), 75% soya bean offal meal (20.33g), 0% soya bean meal, 100% soya bean offal meal (27.1g). The percentage inclusion of each ingredient was calculated using the Pearson square methods. Each ingredient was weighed using a sensitive weighing scale separately. They were mixed and pelleted. The five (5) prepared and formulated experimental diets were moulded into 3mm sized pellets and were labelled separately as diet 1-5 for easy identification in air tight polythene bags as shown in Appendix IV. The experimental diets were stored in a dry place during the experimental duration to avoid nutrients deterioration due to fungal growth (Bolorunduro, 2002).

Feeding the Fingerlings

The fingerlings were starved for 24 hours in order to empty their gastro intestinal tract (G.I.T) and prepare their appetite for the new feed. The experimental fishes were fed at 5% body weight daily with their respective experimental diets. The feed was divided into three portions so that 33% of the feed for a day was given in the morning between 7.00am-8.00am, 33% was given in the evening between 4.00pm-6.00pm and the remaining 33% was given in the mid-night 12:00pm. The quantity of daily ration was adjusted after every two weeks based on fish weight gain for 98 days.

Determination of Growth Performance Parameters

Fish Weight Gain

The weight gain was calculated as the difference between the final weight of the fish at the end of the experiment and the initial weight at the beginning of the experiment.

$$W.G = FW - W_0$$

Where: FW= final weight

W₀ = initial weight

Percentage Live Weight Gain (LWG%)

This was computed as the difference between the initial and final fish weight divided the initial weight expressed as percentage (Mbahinzireki *et al.*, 2001).

$$LGW = \frac{W_t - W_0}{W_0} \times 100$$

Where W₀ = initial fish weight (g)

W_t = Weight at time t days (g)

Specific Growth Rate (SGR)

This was described by Fafioye *et al.* (2005) as

$$SGR = \frac{\text{Log } W - \text{Log } W_0}{t-t_0}$$

Where W, = Weight at the time of observation W₀ = initial weight

t-t₀ = the period under study in days.

Feed Conversion Ratio (FCR)

This was calculated as the dry weight of feed offered divided by the weight

Gain of fish (Mbahinzireki *et al.*, 2001). This was expressed as

$$FCR = \frac{\text{Feed applied (x)}}{\text{Net fish produced (g)}}$$

Gross Food Conversion Efficiency (GFCE)

This is the reciprocal of the FCR expressed as a percentage (Mbahinzireki *et al.*, 2001):

$$\text{Thus: GFCE} = \frac{1}{FCR} \times 100$$

Feed Efficiency (FER)

It was computed as a ratio that expressed the fish weight gain to the quantity of Feed

$$FE = \frac{\text{Weight gain (g)}}{\text{Feed fed (g)}}$$

Protein Efficiency Ratio (PER)

This was computed as a ratio of fish weight gain to the crude protein consumed, as determined Saha and Ray (2011) as

$$PER = \frac{\text{Fish weight gain (g)}}{\text{Crude protein fed (g)}}$$

Apparent Net Protein Utilization (A_{PN}>NPU)

Saha and Ray (2011) was computed as

$$\text{App NPU} = \frac{\text{Fish Protein Gain}}{\text{Protein fed}} \times 100$$

Net Protein Utilization (NPU)

$$NPU = \frac{\text{Fish Protein Gain}}{\text{Protein fed}} \times 100$$

Where; protein gain = final body protein - Initial body Protein.

Protein Consumed = Total dietary protein fed. (Santigosa *et al.*, 2008)

Productive Protein Value (PPV)

This was calculated as a ratio between the protein retained in fish tissue and the Dietary protein consumed (Harpaz *et al.*, 2001). That is:

$$PPU = \frac{\text{Protein retained in tissues}}{\text{Dietary protein consumed}}$$

3.3.11 Nitrogen Metabolism (Nm)

The values of nitrogen metabolism (Nm) was calculated using the Formula of (Lin *et al.*, 2007). It is as follows:

$$Nm = \frac{(0.549Kb-a)h}{2}$$

Where: a = Initial weight of fish (g) b = Final weight of fish (g)

h = Experimental period in days.

Standard Length Gain

The length gain was calculated as the difference between the final length of the fish and the initial length at the beginning of the experiment.

$$SLG = FL - L_0$$

Where: FL = final length

L_0 = initial length

Economic Analyses of Experimental Diets

Konyeme *et al.* (2005) method was adopted. The economic analysis was computed to estimate the cost of feed required to raise a kilogram of fish using various experimental diets.

- I. Estimated Investment cost = Cost of feeding + Cost of fingerlings stocked.
- II. Profit Index = Value of fish (₦) / cost of feed (₦).
- III. Incident of Cost = Cost of feed (₦) / mean weight gain of the produced (g).
- IV. Economic Conversion Ratio (ECR) = Feed Intake x Feed Conversion Ratio

Data Analysis

The student T-test was used to determine the proximate and anti-nutritional compositions of soya bean and soyabean offal meal. The data collected at the end of the experiment was subjected to a one way Analysis of Variance (ANOVA) using the statistical package (SPSS) software version 20.0. The mean was further separated using Duncan's multiple range test at the 95% confidence limit.

Results

The growth parameters as shown in Table 1 observed in this growth study revealed that the Mean Weight Gain (MWG) was apparently highest ($p \leq 0.05$) in T2 (25%) 21.97 ± 4.29^a followed by T1 (0%) 18.42 ± 8.17^b and T4 (75%) 17.33 ± 3.95^b and least in T3 (50%) 13.75 ± 2.01^c and T5 (100%) 12.65 ± 2.93^c . The mean length gain was also higher ($p \geq 0.05$) in T2 (25%) 1.76 ± 0.23^a than T5 (100%) 1.11 ± 0.12^a . The specific growth rate (SGR) was apparently higher ($p \geq 0.05$) in T2 (25%) 0.008 ± 0.3^a and lower in T5 (100%) 0.005 ± 0.4^a all the treatments showed no significant difference ($p \geq 0.05$) in specific growth rate (SGR). There was no significant difference observed in the feed conversion ratio (FCR) of T1 (0%), T2 (25%), T3 (50%), T4 (75%) and T5 (100%) ($p \geq 0.05$). The gross feed conversion efficiency (GFCE) was significantly higher ($p \leq 0.05$) in T2 (25%) 200.00 ± 0.4^a than in T1 (0%) 166.66 ± 0.1^b and T4 (75%) respectively and least in T3 (50%) 142.85 ± 1.2^c and T5 (100%) respectively. There was significant difference in the feed efficiency ratio (FER) among the treatments it was significantly higher ($p \leq 0.05$) in T2 (25%) 1.89 ± 0.4^a and least in T3 (50%) 1.26 ± 0.1^c and T5 (100%) 1.27 ± 0.13^c . There was significant difference in the net protein utilization (NPU), it was significantly higher ($p \geq 0.05$) in T2 (25%) 150.35 ± 0.2^a followed by T1 (0%) 146.53 ± 0.1^b and T3 (50%) 145.17 ± 0.5^b and least in T4 (75%) 134.65 ± 1.2^c and T5 (100%) 115.72 ± 1.4^d . There was also significant difference in the protein efficiency ratio (PER) it was highest ($p \geq 0.05$) in T2 (25%) 0.867 ± 0.5^a followed by T1 (0%) 0.742 ± 0.3^b and T4 (75%) 0.715 ± 0.1^b and least in T3 (50%) 0.555 ± 0.1^c and T5 (100%) 0.503 ± 0.5^c respectively.

Table 1: Growth Rate and Feed Utilization of *O. niloticus* Fed at Different Inclusion Levels

Growth Parameters	T1	T2	T3	T4	T5
MIW (g)	6.27 ± 1.19^a	5.27 ± 1.37^b	5.20 ± 1.20^b	6.67 ± 1.33^a	6.67 ± 1.33^a
MFW (g)	24.69 ± 7.04^b	27.23 ± 4.22^a	18.95 ± 0.92^c	24.00 ± 2.63^b	19.31 ± 1.81^c
MWG (g)	18.42 ± 8.17^b	21.97 ± 4.29^a	13.75 ± 2.01^c	17.33 ± 3.95^b	12.65 ± 2.93^c
MLG (cm)	1.39 ± 0.19^a	1.76 ± 0.23^a	1.36 ± 0.13^a	1.17 ± 0.09^a	1.11 ± 0.12^a
SGR (g)	0.007 ± 0.1^a	0.008 ± 0.3^a	0.006 ± 0.2^a	0.006 ± 0.1^a	0.005 ± 0.4^a
FCR (g)	0.61 ± 0.01^a	0.52 ± 0.02^a	0.78 ± 0.01^a	0.62 ± 0.01^a	0.78 ± 0.04^a
GFCE (%)	166.66 ± 0.1^b	200.00 ± 0.4^a	142.85 ± 1.2^c	166.66 ± 1.3^b	142.85 ± 1.3^c
FER (g)	1.64 ± 0.1^b	1.89 ± 0.4^a	1.26 ± 0.1^c	1.59 ± 0.2^b	1.27 ± 0.13^c
NPU (%)	146.53 ± 0.1^b	150.35 ± 0.2^a	145.17 ± 0.5^b	134.65 ± 1.2^c	115.72 ± 1.4^d

PER (g)	0.742±0.3 ^b	0.867±0.5 ^a	0.555±0.1 ^c	0.715±0.1 ^b	0.503±0.5 ^c

Means with different superscript letter(s) across the rows are significantly different ($p \leq 0.05$)

Key: MFW = Mean Final weight
 MWG = Mean weight gain
 MLG = Mean length gain
 SGR = Specific growth rate
 FCR = Feed conversion ratio
 PER = Protein efficiency ratio
 NPU = Net protein utilization
 FER = Feed efficiency ratio
 GFCR = Gross feed conversion ratio

Discussion

The study was conducted with the aim to evaluate the growth response of *O. niloticus* fingerlings fed soya bean offal meal in various inclusion levels, replacing soya bean meal. The growth performance of the treatments showed that T2 25% inclusion level had the highest Mean Weight Gain (MWG), (SGR) and crude proteins of *O. niloticus* carcass. The highest Mean Weight Gain (MWG) observed in T2 (25%) agreed with partial soya bean meal inclusion diets by Al-Kenawy *et al.* (2008), Borgeson *et al.* (2006), Furuya *et al.* (2004) and El-Saidy and Gaber (2003). The differences were significant ($P < 0.05$). The Mean Length Gain (MLG) was significantly highest in T2, this result disagreed with the results of Umar (2006) who found the Mean Length Gain (MLG) was highest in Diet D (25.41%) of Parboiled senna that had the highest Mean Length Gain MLG value of 1.184 and percentage length gain of 15.260%. The least MLG value came from diet C 0.5% of Raw senna. The differences among the values were significant ($p \leq 0.05\%$). Specific Growth Rate (SGR) was significantly higher in T2 and least in and T5. The study revealed that the Feed Efficiency Ratio (FER) was highest in T2 and also the Net Protein Utilization (NPU) was significantly highest in T2 (25%) (25CP). The Feed Conversion Ratio (FCR) and Gross Feed Conversion Ratio (GFCR) were significantly higher in T2 (25) the differences were significant ($P \leq 0.05$). This was documented by Siddiqui and Khan (2009) who said that the higher the Specific Growth Rate and the smaller the Feed Conversation Ratio. Toasting the seeds (soya bean) at higher temperatures than the recommended values of 121°C-130°C denatures the essential amino acids especially lysine, hence rendering the proteins in soya bean useless at high temperature.

However, at lower temperature, the anti- nutrients were still active. The significant difference observed in the growth parameters was due to nutrients, such as amino acids and minerals, presence of toxic substance or anti-nutrients factors, or decrease of palatability and pallet water stability value in fish diets in some cases reduced growth and poor feed efficiency. Eyo (2001) reported that the use of inferior feedstuffs affect the digestibility and nutritive value of the compounded feeds. Eyo (2001) also was of the opinion that apart from nutrition, other factors such as anti-nutrients could be responsible for low values in growth indices. The growth parameters results obtained in this study agreed with the report of growth and nutrient utilization that were significantly high ($p < 0.05$) in the partially soya bean meal (PSM) and only soya bean meal plus methionine groups(OSM+M) , in contrast to no soya bean meal (NSM)and only soya bean meal group (OSM). This indicates that partial replacement of fish meal with soybean meal did not compromise growth.

Similar result was reported with partial replacement of up to two third of fishmeal with soybean meal in the diet of tilapia (El-Saidy and Gaber, 2002). Similar results were obtained with partial soya bean meal inclusion diets by Al-Kenawy *et al.* (2008), Borgeson *et al.* (2006), Furuya *et al.* (2004) and El-Saidy and Gaber (2003). However, total replacement caused a reduction in growth and feed utilization as exhibited by the only Soya bean Meal (OSM) groups. Soya bean was reported to contain approximately 30% carbohydrate of which oligosaccharides make up 10% and Non Starch Polysaccharides (NSP) make up the remaining 20% (Storebakken *et al.* 2000). The carbohydrates are not digestible by monogastric animals, with some components having antinutritional effects. The low growth and nutrient utilization in fish fed diet with complete replacement of fishmeal with soya bean meal could be attributed to an increase in the carbohydrate component of the diet. Also, Koumi *et al.* (2008) observed lower growth in *O. niloticus* when fishmeal was totally replaced by soya bean meal. Davis *et al.* (2005) reported a decrease in growth response of juvenile red snapper, *Lutjanus campechanus* when soya bean meal was totally used as a replacement for fishmeal. Methionine supplement improved growth and nutrient utilization parameters in *O. niloticus*.

This result is in agreement with Francis *et al.* (2001) who reported improved growth when diets of tilapia were supplemented with crystalline methionine. In contrast, El-Saidy and Gaber, (2002) reported that feeding blue tilapia and Nile tilapia, respectively with 100% SBM, firstly with or without methionine supplementation had no significant effect on growth parameters and feed utilization. Meanwhile, the reduced growth rate observed in the no soya beans meals NSM group could be due to the fact that *O. niloticus* has a preference for plant protein as it possesses morphological and physiological adaptations for diets high in fibre content. Ayoola, (2010) opined that the protein quality of the feed fed the fish determines whether the feed material accepted by the fish is balanced or not. Proximate analysis of the carcass of partially soya beans meals PSM group revealed high percentage dry matter and crude protein. The highest crude fat and ash was obtained in soya beans meals plus methionine SBM+M group and this may be due to the availability of sufficient energy in the diet. This assertion is supported by Abdelghany (2003), who reported that diets containing soya bean meal for *O. niloticus* increased body crude protein.

Conclusion

Nile tilapia (*O. niloticus*) growth was better in T2 (25.34CP) (25%) Soya bean offal Inclusion had the highest Mean Weight Gain (21.97 ± 4.29^a g), Mean Length Gain (MLG) of (1.7 ± 0.23^a cm), Protein Efficiency Ratio (PER) of (0.867 ± 0.5^a g), Net Protein Utilization (NPU) of (150.35 ± 0.2^a %) Gross feed conversion efficiency (GFCE) of 200.00 ± 0.4^a and crude protein of *O. niloticus* carcass (38.1 ± 0.20^a g/100g DM). This indicated that T2 25% inclusion (25.34 ± 1.93^a CP) is the best diet that support the growth of *O. niloticus* during the experiment. The study demonstrated that soybean offal meal could replace the soya bean meal in diet for Nile tilapia reared in plastic rearing tanks without negative effects on growth, or on total production and even leading to high net economic returns.

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References

- Abdelghany, A. E. (2003). Partial and Complete replacement of Fishmeal with Gambusia meal in diets of Red Tilapia (*Oreochromis niloticus* X *O. mossambicus*). *Aquaculture Nutrition*, **9**:145-151.
- Abu, O. M. G., Sanni, L. O., Erundu, E. S. and Akinrotimi, O. A. (2010). Economic viability of Replacing Maize with whole Cassava Root Meal in the Diet of Hybrid Cat- fish. *Agricultural Journal*, **5** (1): 1-5.
- Agbo, N. W., Madalla, N. and Jauncey, K. (2015) Mixtures of Oil Seed Meals as dietary Protein sources in diets of Juvenile Nile Tilapia (*Oreochromis niloticus* L.). *Journal of Science and Technology (Ghana)*, **35**(3): 11-24.
- Al-Kenawy, El-Nagar, D. G. and Mohamed, Y. A. Z. (2008). Total replacement of Fishmeal with Soybean Meal in diets for Nile Tilapia in pre-fertilized Ponds. *Proceedings of the 8th International Symposium on Tilapia in Aquaculture*, October 12-14, 2008, The World Fish Center, pp: 773-785.
- Ayoola, S. O. (2010). Utilization of compounded feed and Poultry Hatchery waste in the diet of (*Clarias gariepinus*). *Nigerian Journal of Fisheries*, **8**: 291-299.
- Borgeson, T. L., Racz, V. J. Wilkie, D. C. White, L. J. and Drew, M. D. (2006). Effect of replacing Fishmeal and oil with simple or complex mixtures of Vegetable ingredients in diets fed to Nile tilapia (*Oreochromis niloticus*). *Aquaculture Nutrition*, **12**: 141-149.
- Davis, D.A., Jirsa, D. and Arnold, C.R. (2005). Evaluation of Soybean Proteins as replacements for menhaden Fish Meal in practical diets for the Red drum (*Sciaenops ocellatus*). *Journal of World Aquaculture Society*, **26**:48-58.
- El Saidy, D. M. and Gaber, M. M. (2002). Complete replacement of Fish Meal by Soybean Meal with dietary L-lysine supplementation for Nile Tilapia (*Oreochromis niloticus*) (L.) Fingerlings. *Journal of the World Aquaculture Society*, **33**(3): 297-306.
- El-Saidy, D. M. S. D. and Gaber, M. M. A. (2003). Replacement of Fish Meal with a mixture of different Plant Protein sources in Juvenile Nile Tilapia, (*Oreochromis niloticus*) (L.) diets. *Aquaculture Research*, **34**: 1119-1127.

- Eyo, A. A. (2001). Fish Processing Technology in the tropics. National Institute for Freshwater Fisheries Research. University of Ilorin Press. pp66-70.
- Fagbenro, O. A., Jegede, T. and Fasasi, O. S. (2010). Tilapia aquaculture in Nigeria. *Applied Tropical Agriculture*, **15**: 49-55.
- FAO (2006). *State of world aquaculture* FAO Fisheries Technical Paper, No. 500. Rome, P. 134.
- Francis, G., Makkar, H. P. and Becker, K. (2001). Antinutritional factors present in Plant-derived alternate Fish feed ingredients and their effects in Fish. *Aquaculture*, **199**(3-4): 197-227.
- Furuya, W. M., Pezzato, L. E. Barros, M. M. Pezzato, A. C. Furuya, V. R. B. and Miranda, E. C. (2004). Use of ideal Protein concept for precision formulation of Amino acid levels in Fish-Meal-free diets for Juvenile Nile Tilapia (*Oreochromis niloticus* L.). *Aquaculture Research*, **35**: 1110-1116.
- Jamiu, D. M. and Ayinla, O. A. (2003). *Potential for the development of Aqua-culture in Africa* NAGA, **26** (3): 9 – 13.
- Koumi, A. R., Atse, B. C. and Koume, L. P. (2008). Utilization of Soya Protein as an alternative Protein source in *Oreochromis niloticus* diet: Growth performance, feed utilization, Proximate composition and Organoleptic characteristics. *African Journal of Biotechnology*, **8**: 91-97.
- Krome, C. A., Jauncey, K. and Focken, U. (2016). *Jatropha curcas* Kernel as a replacement for Fish Meal in a practical Nile Tilapia, (*Oreochromis niloticus*) feeds. *Aquaculture, Aquarium, Conservation and Legislation*, **9** (3): 590-596.
- Ng, W. K. and Romano, N. (2013). A review of the Nutrition and Feeding management of Farmed Tilapia throughout the culture cycle. *Reviews in Aquaculture*, **5**(4): 220-254.
- Olukunle, O. (2006). Nutritive potential of Sweet Potato Peel Meal and Root replacement value for Maize in diets of African Catfish (*Clarias gariepinus*) advanced fry. *Journal of Food Technology*, **4**(4): 289 – 293.
- Storebakken, T., Refstie, S. and Ruyter, B. (2000). Soy products as Fat and Protein sources in Fish Feeds for intensive aquaculture. Soy in Animal Nutrition Fed. *Animal Science Society*., Savoy, IL, USA, 127-170.
- Umar, R. (2006). Growth Performance of Nile Tilapia (*Oreochromis niloticus*) fed Perboiled Senna at different inclusion levels: An unpublished M.SC. Thesis Ahmadu Bello University, Zaria. 52-59.

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Utilization of Spent Sorghum (*Sorghum bicolor*) From Locally Fermented Drink (Burukutu) As Experimental Diet for *Clarias gariepinus* Fingerlings

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Abstract:

Brewer's waste is one of the promising by-product from carbohydrate and protein sources used for fish diet. A 10 week feeding trial experiment involving 10 different diets (10 diets of Spent sorghum locally fermented drink Burukutu) with increasing levels of brewer's waste (40% crude protein) was carried out to evaluate the use of spent Sorghum, from Burukutu production in *Clarias gariepinus* diets as a substitute for Corn. Growth performance was compared against a control diet formulated to have similar composition to a typical commercial diet. 10 experimental diets replaced successively 0%, 10%, 20%, 30%, 40%, 50%, 70%, 80%, 90%, and 100% of the Corn carbohydrate with spent sorghum from locally fermented drink, Burukutu. The diets were isonitrogenous and isocaloric. A relatively good growth performance and nutrient utilization by *Clarias gariepinus* fingerling fed the test diets were observed. However, the results showed significant difference ($p < 0.05$) in weight gain, SGR, FCR and RGR between treatments, with the control performing best. The result also showed that survival rate was high in all the treatment which indicate that, spent sorghum from burukutu production has no adverse effect on *Clarias gariepinus*. Based on this research, it was concluded that 50% of the corn carbohydrate in a typical commercial diet could be replaced with spent sorghum from locally fermented drink (Burukutu) with no adverse effect on growth and feed utilization for the specie.

Keywords: Spent Sorghum, Burukutu, Growth response, Nutrient utilization and *C. gariepinus*.

Introduction

The current trend of inflation worldwide has become a basic concern for livestock owners, inflation often imposes adverse effects on livestock feeds and hence, on costs of producing livestock and livestock products (Nyannor et al., 2007), the growth of aquaculture is restrained by the low availability and higher price of all quality aqua feed ingredients. Several attempts have been made by researchers to increase the utilization of nonconventional plant and animal materials to replace conventional feed ingredients like corn and fish meal in fish feed rations (Baruah et al., 2003; Eyo, 2004; Eyo & Ezechie, 2004; Abu et al., 2010). Corn, although widely cultivated has been extensively utilized as human food, feed for livestock and raw materials for industries (Eyo & Ezechie, 2004). In Nigeria, the demand for corn is in excess production, and the utilization of corn as major basal ingredient in the aquaculture industries will place more constraint on an already over exploited resource. There is therefore, the need to exploit cheaper energy sources to replace expensive corn in fish feed formulation.

Materials and Method

Study Area

The experiment was conducted in Anyigba, Kogi State. Anyigba is a town in Dekina local government area of Kogi State with the headquarter in Dekina town.

Source and processing of brewer's waste

Spent Sorghum was sourced from a local gin producer at Agume in Dekina Local Government and Ejegbo in Anka Local Government. Brewer's waste in fresh form contains about 80-85 % moisture, the waste was sundried for 7 days with regular turning to prevent mold. The sundried brewer's waste was milled and taken for proximate analysis. The milled product was then mixed with other feed ingredients (fish meal, soybean meal, corn, vitamin/mineral premix) and grinded together. Ingredients used in the feeding trial: fishmeal, soybean meal, corn,

vitamin/mineral premix, were bought from Ilorin market, Kwara State, Nigeria. These ingredients were separately milled, screened with fine mesh net to fine particle size (<250 µm).

Experimental diets: (Ten (10) isonitrogenous experimental diets were formulated. The diets contained progressively increasing levels of spent sorghum (SSG) from Burukutu (BKT) production and were used for the feeding trial experiment. The experimental diets were formulated to produce diets in which 0% (SSG0), 10% (SSG10), 20% (SSG20), 30% (SSG30), 40% (SSG40), 50% (SSG50) 70% (SSG70) 80% (SSG80) 90% (SSG90) and 100% (SSG100) of carbohydrate from corn were replaced with that from Spent Sorghum (SSG).

Table 1: Percentage composition of experimental diet fed to *Clarias gariepinus* (Spent Sorghum)

	DIETS									
	0%	10%	20%	30%	40%	50%	70%	80%	90%	100%
INGREDIE										
NTS (%)										
Fish meal	36.70	36.50	36.33	36.13	35.94	36.51	35.32	35.10	34.90	34.67
Soya bean	24.47	24.35	24.21	24.09	23.95	23.82	23.54	23.41	23.25	23.11
Maize	34.83	31.63	28.37	25.05	21.67	18.22	11.14	7.50	3.79	0.00
Spent sorghum	0	3.51	7.09	10.74	14.45	18.22	25.99	29.99	34.07	37.68
Vit/Min.	2	2	2	2	2	2	2	2	2	2
Starch	2	2	2	2	2	2	2	2	2	2

Culture condition: Fish were sorted, weighed (using a sensitive weighing balance) and randomly stocked into the experimental bowls. Twelve (12) fish were stocked per bowl. They were starved overnight before commencing the feeding trials. At the end of acclimation, fish specimen in each bowl was weighed to determine their initial mean weight. Fish were offered 5% of their body weight.

Experimental set up: (10) different treatments with three replicates were used for the experiment. total of 30 bowls containing (12) fish for each bowl, making a total of 360 fingerlings were used for the first experiment. Temperature, dissolved oxygen and pH was monitored through the 10 weeks of the experiment.

Proximate Analysis: The nutritional compositions of SSG sample were analyzed in triplicate according to standard procedures given I Association of Official Analytical Chemists (AOAC, 1980).

Feed evaluation parameters:

The following growth and nutrient utilization parameters were calculated as measures of the effectiveness of utilization of SSG meal as a replacement for corn in the diet of *Clarias gariepinus*. Mean weight gained, specific growth rate, feed conversion ratio, average daily weight, feed conversion efficiency, protein efficiency ratio.

Results

Growth parameters of the experimented fish

The result for the growth response and feed utilization data of *Clarias gariepinus* fed (10) diets of spent sorghum (SSG) from BKT production is presented in Table 2.

Fish fed the control diets had the highest mean weight gain of 65.87g followed by fish fed 10% SSG at 53.97g. Mean weight gain of 34.34g was recorded for fishes fed diet containing 20% SSG meal. Mean weight gain of 32.67g, 32.47g, 32.28g, 27.56g, 25.57g, 26.36g and 22.34g were recorded in fishes fed diets containing 40%, 50%, 70%, 80%, 90% and 100% SSG meal respectively. The highest weight gained was recorded in fish with control diet at 65.87g, the lowest weight gain was observed in fishes fed 100% SSG meal at 22.34g. The result for the specific growth rate (SGR) showed that fishes fed with control diet had the highest value 94.10, followed with fishes fed with 10% SS meal at 77.10. The lowest value we recorded in fishes fed 100% and 90% at 31.91 and 33.13 respectively.

The feed conversion ratio (FCR) was increasing with increase of SSG in the diets. With the control having the lowest value of 3.13 while the highest value was observed in 100% SSG meal at 4.66

Table 2: Growth response and nutrient utilization of feeding *C. gariepinus* with spent Sorghum based diets for 10 weeks

Parameter	DIETS									
	0%	10%	20%	30%	40%	50%	70%	80%	90%	100%
MIW(g)	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33
MFW(g)	74.20±3.82 ^a	62.30±1.27 ^b	42.67±1.33 ^c	41.00±1.5 ^c	40.50 ± 1.89 ^c	40.61± 0.30 ^c	35.89 ± 1.45 ^{cd}	33.90 ± 3.09 ^d	31.52 ± 0.80 ^d	30.67 ± 0.67 ^d
MWG (g)	65.87 ± 3.82 ^a	53.97 ± 1.27 ^b	34.34 ± 1.33 ^c	32.67 ± 3.50 ^c	32.47 ± 1.89 ^{cd}	32.28 ± 0.30 ^{cd}	27.56 ± 1.45 ^{cde}	25.57 ± 3.09 ^{de}	23.85 ± 1.14 ^e	22.34 ± 0.66 ^e
SGR	1.33±0.06 ^a	1.25 ± 0.05 ^a	1.01 ± 0.04 ^a	0.98 ± 0.04 ^b	0.98 ± 0.04 ^b	0.98 ± 0.04 ^b	0.91± 0.03 ^c	0.87 ± 0.02 ^{cd}	0.83 ± 0.01 ^d	0.81 ± 0.01 ^d
FCR	3.13 ± 0.18 ^d	3.24 ± 0.12 ^{cd}	4.14 ± 0.17 ^{cb}	3.57 ± 0.44 ^{cbcd}	3.84 ± 0.21 ^d	4.39 ± 0.05 ^{ab}	3.96 ± 0.21 ^{bc}	4.45± 0.49 ^{ab}	5.15 ± 0.16 ^a	4.66 ± 0.03 ^{ab}
FCE	32.15 ± 1.83 ^a	30.96 ± 1.17 ^{ab}	24.21 ± 0.95 ^{dc}	26.64 ± 3.43 ^{cb}	26.22 ± 1.47 ^{bc}	22.78 ± 0.23 ^{cd}	25.38 ± 1.42 ^c	21.32 ± 2.64 ^{cd}	19.45 ± 0.58 ^d	21.45 ± 0.13 ^{cd}
Survival rate	75.00 ± 4.81 ^{cd}	72.22 ± 2.78 ^d	88.89 ± 5.56 ^{abc}	80.56 ± 7.35 ^a	80.56 ± 2.78 ^{abcd}	91.67± 0.00 ^{ab}	72.22 ± 2.78 ^d	91.67 ± 4.81 ^{ab}	94.45± 2.78 ^{ab}	77.78 ± 5.60 ^a

Mean within the same row with different superscripts are significantly different (P<0.05); SEM = Standard Error of Means

Table3: Proximate composition of spent sorghum from locally fermented drink (Oburukutu)

Parameters	Moisture	Ash content	Fibre content	Fat content	Crude protein	carbohydrate
Proximate composition	8.35±0.01	7.26±0.01	5.67±0.06	3.53±0.02	10.96±0.00	64.07±0.02

Table 4: Weekly water quality parameters throughout duration of the experiment

Weeks	1	2	3	4	5	6	7	8	9	10
DO	5.30	5.61	6.00	5.80	5.50	6.12	6.33	5.40	5.83	5.85
pH	7.91	8.13	7.70	7.82	8.00	8.30	7.81	7.61	8.33	8.26
T(C)	20.33	21.22	22.43	21.43	22.53	22.00	22.43	22.65	21.40	22.45

Discussion

Brewery waste, a by-product of brewery industry, is high in nutritional value. Previously, it had been considered to be an industrial waste that required special treatment. The results of the present study showed that the inclusion level of SSG up to 70 % had no negative effect on growth response as represented by final weight, weight gain, SGR and survival compared to the control diets. However, FCR was affected by feeding different inclusion levels of spent sorghum from BKT production. Poor feed efficiency in experimental feed containing high SSG can be explained by the less palatability of the diets when the feed contains a high level of the spent grain from BKT (Eyo&Ezechie, 2004). It has also been reported that different starch and protein sources affected the physical quality of fish diets which can in turn affect its palatability and acceptability (Øverland et al. 2009; Sørensen et al., 2010).

Conclusion

The present results showed that the nutrient components and energy in the spent sorghum were relatively well digested by the experimental fish (*C. gariepinus*). It could therefore be suggested that spent sorghum meal from BKT production could be used for partial replacement of corn meal in the diets for *C. gariepinus*, as they have a good digestible protein and carbohydrate content.

Recommendation

Based on the result of this study, spent sorghum from locally fermented drink (Burukutu) in the diets of *Clariasgariepinus* up to 50% is recommended to fish farmers in order to maximize their profits without any adverse effect on the fish.

References

- AOAC, 1980. Official Methods of Analysis. 13th Edn., Association of Analytical Chemist, Washington, DC., USA., pp :56-132
- Baruah, K. Sahu N.P. & Debnath D. (2003). Dietary phytase: An ideal approach for a cost effective and low polluting aquafeed. *NAGA*, 27(3): 15 -19.
- Brown, M.E. (1975). Experimental Studies on Growth. The physiology of fishes. In: Brown M.E. (ed). Vol. I Academic Press, London 401pp.
- Eyo, J. E. & Ezechie, C. V. (2004). The effects of rubber (*Haveabrasiliensis*) seed meal based diets on diets acceptability and growth performance of *Heterobranchusbidorsalis* (male) x *Clariasgariepinus*(female) hybrid. *Journal of sustainable Tropical* 13: 20-24
- Nyannor, E.K.D., Adedokun, S.A., Hamaker, B.R., Ejeta, G & Adeola, O. (2007). Nutritional evaluation of high digestible sorghum for pigs, *Journals of Animal Science*, 85: 196-203. *Obesity*, 17, 40–45.
- Øverland, M., Sørensen, M., Storebakken, T., Penn, M., Krogdahl, A., & Skrede, A. (2009). Pea protein concentrate substituting fish meal or soybean meal in diets for Atlantic salmon (*Salmosalar*): effect on growth performance, nutrient digestibility, carcass composition, gut health, and physical feed quality. *Aquaculture*, 288: 305 - 311.
- Sørensen, M., Morken, T., Kosanovic, M., & Øverland, M. (2010). Pea and wheat starch possess different processing characteristics and affect physical quality and viscosity of extruded feed for Atlantic salmon. *Aquaculture Nutrition*, 17: 1 - 11.

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Utilization of Spent Maize as Experimental Diet for *Clarias gariepinus* Fingerlings**Ogbe, K.U., Omada, O.I and Dasuma, E**

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Abstract

A 70-day study was conducted to evaluate the possibility of replacing maize with spent maize (SMZ) in the diet of African cat fish (*Clarias gariepinus*). The experiment evaluated growth performance for replacement of maize with spent maize (SMZ). Ten isonitrogenous diets were formulated. SMZ was added to the diet to replace maize at graded levels; 0%, 10%, 20%, 30%, 40%, 50%, 70%, 80%, 90% and 100%. Total of 360 fish ($8.330 \pm 0.00g$) were randomly assigned to the five treatment diets. Each treatment contained 10 fish per bowls and each treatment was triplicated in a completely randomized design (CRD). Fish were fed twice daily at 5% body weight in equal proportions. Results showed significant differences ($P < 0.05$) for measured growth parameters. Fish fed diet containing 0% SMZ had the highest mean weight gain ($57.41 \pm 2.13g$), specific growth rate (SGR) (2.50), best feed conversion ratio (FCR) ($3.68 \pm 0.13\%$) and feed conversion efficiency (FCE) ($27.28 \pm 1.01\%$) compared to other treatments. Fish farmers can utilize spent maize in their feed formulation up to 50%.

Keywords: spent maize, Growth response, Nutrient utilization and *C. gariepinus*.

Introduction:

The African catfish, *Clarias gariepinus*, is rated as being among the most economically important food fish regularly cultured in Africa (Okomoda et al., 2018). This can be linked to certain qualities of the fish, which includes its high fecundity, growth performance, tolerance to environmental stresses, and a relatively attractive price per kilogram (Tsfahun, 2018). Good growth performance under captivity is based on the feeding of a high-quality protein diet. (Olufeagba, 2016). Hence, to meet the nutritional requirement of the fish, expensive feed ingredients such as fishmeal, Soy beans, Corn etc are used, consequently, leading to high production cost (Pelletier, 2018). Therefore, to ensure a profitable catfish venture, there is a need to seek alternative quality feed ingredients that can be used in place of expensive fish ingredients without compromising the optimum growth of the fish (Adeshina et al., 2020).

Adequate utilization of carbohydrates in the fish diet contributes to good use of proteins for fish growth, as well as reducing the elimination of nitrogenous residues (Asaduzzaman et al., 2010). In addition, the use of carbohydrates, when balanced with proteins and lipids in fish diets, may reduce the amount of protein in the diet formulation (Hemre et al., 2002), reducing feed cost, as protein is one of the most expensive dietary items in the fish diet. Therefore this study seek to utilize spent maize (SMZ) as experimental diets for *Clarias gariepinus* Fingerlings.

Materials and Method**Study Area**

The experiment was conducted in Anyigba, Kogi State. Anyigba is a town in Dekina local government area of Kogi State with the headquarter in Dekina town.

Source and processing of spent maize

Spent maize was sourced from Egume in Dekina Local Government and Ejegbo in Ankpa Local Government. Spent maize in fresh form contains about 80-85 % moisture, the waste was sundried for 7 days with regular turning to prevent mold. The sundried SMZ was milled and taken for proximate analysis. The milled product was then mixed with other feed ingredients (fish meal, soybean meal, corn, vitamin/mineral premix) and grinded together. Ingredients used in the feeding trial: fishmeal, soybean meal, corn, vitamin/mineral premix, were bought from Ilorin market, Kwara State, Nigeria. These ingredients were separately milled, screened with fine mesh net to fine particle size ($< 250 \mu m$).

Experimental diets: (Ten (10) isonitrogenous experimental diets were formulated. The diets contained progressively increasing levels of spent maize (SMZ) and were used for the feeding trial experiment. The experimental diets were formulated to produce diets in which 0% (SMZ0), 10% (SMZ10), 20% (SMZ20), 30% (SSMZ30), 40% (SMZ40), 50% (SMZ50) 70% (SMZ70) 80% (SMZ80) 90% (SMZ90) and 100% (SMZ100) of carbohydrate from Maize were replaced with that from Spent maize (SMZ).

Table 1: Percentage composition of experimental diet fed to *Clarias gariepinus* (spent maize)

	DIETS									
	0%	10%	20%	30%	40%	50%	70%	80%	90%	100%
INGRIDENTS (%)										
Fish meal	36.70	36.72	36.76	36.78	36.79	36.82	36.87	36.70	36.91	36.93
Soya beans	24.47	24.48	24.49	24.51	24.54	24.55	24.58	24.59	24.62	24.64
Maize	34.83	31.32	27.80	24.30	20.80	17.32	10.37	7.02	3.45	0.00
Spent maize	0	3.50	6.95	10.41	13.87	17.32	24.19	27.62	31.02	34.43
Vit/min.	2	2	2	2	2	2	2	2	2	2
Starch	2	2	2	2	2	2	2	2	2	2

Culture condition: Fish were sorted, weighed (using a sensitive weighing balance) and randomly stocked into the experimental bowls. Twelve (12) fish were stocked per bowl. They were starved overnight before commencing the feeding trials. At the end of acclimation, fish specimen in each bowl was weighed to determine their initial mean weight. Fish were offered 5% of their body weight.

Experimental set up: (10) different treatments with three replicates were used for the experiment. total of 30 bowls containing (12) fish for each bowl, making a total of 360 fingerlings were used for the first experiment. Temperature, dissolved oxygen and pH was monitored through the 10 weeks of the experiment.

Proximate Analysis: The nutritional compositions of SMZ sample were analyzed in triplicate according to standard procedures given I Association of Official Analytical Chemists (AOAC, 1980).

Feed evaluation parameters:

The following growth and nutrient utilization parameters were calculated as measures of the effectiveness of utilization of SMZ meal as a replacement for corn in the diet of *Clarias gariepinus*. Mean weight gained, specific growth rate, feed conversion ratio, average daily weight, feed conversion efficiency, protein efficiency ratio.

Results

Growth Parameters of the Experimental Fish

The result for the growth response and feed utilization data of *Clarias gariepinus* fed 10 diets of spent Mize (SMZ) (from Burukuto production is presented in Table 2. Fish fed with Diet1 had the highest mean weight gain of 57.41g. The lowest weight gain was observed in fish fed with Diets 10 at 22.86g. There was significant differences in weight gain across the treatment of SMZ administered ($p < 0.05$). The results for Feed Conversion Ratio (FCR) showed that there was a significant difference ($p < 0.05$) among the treatments and the highest value was observed in Diet 10 at 5.00g while the lowest was observed in Diet 1 at 3.68g. The results for Feed Conversion Efficiency (FCE) showed that there was a significant difference ($p < 0.05$) among the treatments. The highest value was observed in Diet 1 at 27.28% while the lowest was observed in Diet 6 at 20.02%. The results for specific growth rate (SGR) showed that there was a significant difference ($p < 0.05$) across the treatments. The highest value was observed in Diet 1 at 2.50 % while the lowest was observed in Diet 10 at 1.93%.

Table 2: Growth response and nutrient utilization of feeding *C. gariepinus* with spent maize based diets for 10 weeks

Parameter	DIETS									
	0%	10%	20%	30%	40%	50%	70%	80%	90%	100%
MIW(g)	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33
MFW(g)	65.75±2.1 3 ^a	60.90±0 .00 ^b	55.60±0 .00 ^c	53.26± 2.13 ^c	44.02±0 .72 ^d	41.24 ± 1.46 ^d	35.90± 1.45 ^e	33.17 ± 0.67 ^{ef}	32.00 ± 2.0 ^{ef}	31.19 ± 0.81 ^f
MWG (g)	57.41 ± 2.13 ^a	53.57 ± 1.00 ^a	47.27 ± 0.00 ^b	44.93± 2.13 ^b	35.69 ± 0.72 ^c	32.91± 1.46 ^c	27.56 ± ± 1.45 ^d	24.84± 0.67 ^{de}	23.67 ± 2.00 ^{de}	22.86 ± 0.81 ^e
SGR	2.50	2.45	2.38	2.34	2.20	2.15	2.03	1.96	1.93	1.93
FCR	3.68 ± 0.13 ^b	3.91 ± 0.13 ^b	3.34 ± 0.00 ^c	4.49 ± 0.14 ^a	4.59 ± 0.09 ^a	4.53 ± 0.21 ^a	3.91 ± ±0.18 ^b	4.82 ± 0.12 ^a	4.66 ± 0.36 ^a	5.00 ± 0.14 ^a
FCE	27.28 ± 1.01 ^{ab}	25.65 ± 0.83 ^b	29.92 ± 0.00 ^a	22.34 ± 0.71 ^c	21.83± 0.44 ^c	20.46 ± 1.55 ^c	25.73 ± ± 2.00 ^b	19.55 ± 0.68 ^c	20.32 ± 1.72 ^c	20.02 ± 0.57 ^c
JSurvival rate	88.89 ± 2.78 ^a	88.89 ± 2.78 ^a	75.00 ± 0.00 ^b	97.22 ± 2.78 ^a	97.22 ± 2.78 ^a	94.45 ± 2.78 ^a	72.22± 2.78 ^b	97.22 ± 2.78 ^a	94.45 ± 5.56 ^a	94.45 ± 2.78 ^a

Mean within the same row with different superscripts are significantly different (P<0.05); SEM = Standard Error of Means

Table 3: Proximate composition of spent maize from locally fermented drink (Oburukutu)

Parameters	Moisture	Ash content	Fibre content	Fat content	Crude protein	Carbohydrate
Proximate composition	7.33±0.02	7.08±0.07	4.73±0.04	3.54±0.02	9.96±0.00	67.34±0.00

Table 4: Weekly water quality parameters throughout duration of the experiment

WEEKS	1	2	3	4	5	6	7	8	9	10
DO	5.31	5.72	6.00	5.80	5.50	6.12	6.33	6.40	5.80	5.80
pH	7.94	7.13	7.70	7.82	8.00	8.30	7.80	7.61	8.34	8.20
T(C)	20.33	21.22	22.43	21.43	22.53	21.00	22.00	22.65	21.40	22.40

Discussion

Physiochemical parameters

The pH is a major factor that determines the growth of micro organisms. The pH measurement helps to determine if the water is a proper environment for fish, plant and algae. The pH obtained from this study is within the range of 7.13 and 8.34 for all the dietary treatments, Required for aquaculture as reported by Njoku et al. (2015), Ehiagbonare and ogunrinde (2010). The temperature obtained from this study ranged from 20⁰C -23⁰C which was within the limit that support fish productivity. Nteguw and Edema (2008) has reported the optimum temperature 20⁰C -30⁰C for increased productivity. This finding disagreed the reports of fafioye (2011) who observed a temperature of 27⁰C -28⁰C in the preliminary studies and water characteristics microbial population in fish ponds. This may be as a result of seasonal variations. The dissolved oxygen (DO) obtained, range from 5.31mg/l and 6.40mg/l. The result obtained from this study is similar to the result obtained from Onome and Ebinimi (2010), who reported the DO of 4.34mg/l and 6.33mg/l. This DO is in line with Saloom and Duncan (2005) who suggested that the minimum DO should be 5mg/l for tropical fish.

Feed evaluation parameters

There was a decrease in mean weight gain and feed conversion efficiency across the treatment with an increase inclusion of spent maize. The results of this study disagree with the observation made by Nwanna et al. (2009), who reported that very high inclusion levels of unconventional dietary carbohydrate sources often result in poor performance of the fish. The result of this study disagree with Nwanna et al. (2004) who reported that replacing maize with a non-conventional carbohydrate source tamarind (*Tamarindus indica*) resulted in good growth performance of catfish and improved economic returns. The decrease in growth as a result of high inclusion of spent

maize maybe as a result of less palatability of the feed with increase quantity of spent maize in the diet. The result of this present study show a good survival rate across the treatment, which may be as a result of proper fish management, and handling.

Conclusion and Recommendation:

The present results showed that, there was a good growth performance up to 50% of inclusion level of spent maize in the diet of *Clarias gariepinus* with a good survival rate. Fish farmers are encouraged to explore this opportunity as it will reduce drastically the cost of fish production and enhance growth of fish as well.

References

- Adeshina, I., Abubakar, M.I.O., & Ajala, B.E. (2020). Dietary supplementation with *Lactobacillus acidophilus* enhanced the growth, gut morphometry, antioxidant capacity, and the immune response in juveniles of the common carp, *Cyprinus carpio*. *Fish. Physiology and Biochemistry*, 46: 1375–1385.
- AOAC, 1980. Official Methods of Analysis. 13th Edn., Association of Analytical Chemist, Washington, DC., USA., pp :56-132
- Asaduzzaman, K., Mousumi, T., Dian-Zheng, Z., & Han-Chun, C., (2010). Antioxidant enzymes and cancer. *Chin. J. Cancer Res.* 22, 87–92.
- Ehiagbonare, J. E., Ogunrinde, Y. O. (2010). Physicochemical Analysis of Fish Pond in Okada and its Environs. Nigeria, *African Journal of Biotechnology*, 36: 5922 - 5928.
- Fafioye, O. O. (2011). Preliminary Studies on Water Characteristics and Bacterial Population in High Yield Kajola Fish Ponds. *Journal of Agriculture Extension and Rural Development*, 3: 68 – 71
- Hemre, G.I., Mommsen, T.P., Kroghdahl, A. (2002). Carbohydrates in fish nutrition: effects on growth, glucose metabolism and hepatic enzymes. *Aquacult. Nutr.* 8, 175–194.
- Njoku, O. E., Agwa, O.K. & Ibiene, A. A. (2015). An Investigation of the Microbiological and Physicochemical Profile of Some Fish Pond Water within the Niger Delta Region of Nigeria. *European Journal of Food Science and Technology*, 3: 20-30
- Nwanna L, Fagbenro O., & Olanipekun S. (2004). Evaluation of tamarind (*Tamarindus indica*) seed meal as a dietary carbohydrate for the production of Nile tilapia *Oreochromis niloticus* (L). *Anim R Int* 1(3): 164 - 168.
- Nwanna LC1, Falaye AE, Olarewaju1OJ, Oludapo1 BV. (2009). Evaluation of Nile tilapia (*Oreochromis niloticus* L) fed dietary potato peels as replacement for yellow maize. Paper presented at: 24th Annual Conference of the Fisheries Society of Nigeria (FISON); Akure, Nigeria.
- Okomoda, V.T., Koh, I.C.C., Hassan, A., Amornsakun, T., & Shahreza, M.S. (2018). Performance and characteristics of the progenies from the crosses of *Pangasianodon hypophthalmus* (Sauvage, 1878) and *Clarias gariepinus* (Burchell, 1822). *Aquaculture*, 489: 96–104
- Olufeagba, S.O., Okomoda, V.T. (2016). Cannibalism and performance evaluation of hybrids between *Clarias batrachus* and *Clarias gariepinus*. *Croatian Journal of Fish*, 74: 124–129.
- Onome, A. D. & Ebinimi, A. (2010). Comparative Assessment of Water Quality Parameters of Fresh Water Tidal Earthen and Stagnant Concrete Tanks for Fish Production in Port Harcourt, Nigeria. *International Journal of Science and Nature*, 11: 34- 37
- Pelletier, N., Klinger, D.H., Sims, N.A., Yoshioka, J.R., & Kittinger, J.N. (2018). Nutritional attributes, substitutability, scalability, and environmental intensity of an illustrative subset of current and future protein sources for aquaculture feeds: Joint consideration of potential synergies and trade-offs. *Environ. Sci. Technol*, 52: 5532–5544
- Saloom, M. E., and Duncan, R. S. (2005). Low dissolved oxygen levels reduce anti-predator behaviours of the fresh water Clam *Corbicula fluminea*. *Fresh Water Biology journal*. 50: 1233-1238
- Tesfahun, A. (2018). Feeding biology of the African catfish *Clarias gariepinus* (Burchell) in some of Ethiopian lakes. A review. *Int. J. Fauna. Biol. Study*, 5: 19–23.

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Proximate Composition of Cultured and Wild *Heterobranchus longifilis***Agbo, A.N and Awolumat S**

National Open University of Nigeria, Faculty of Agricultural Sciences, Kaduna

Corresponding author: +2348028191262 ronkeagbo@gmail.com**Abstract**

The proximate composition of wild and cultured *Heterobranchus longifilis* were analysed. Twenty (20) fish samples of cultured and wild *Heterobranchus longifilis* were analysed for crude protein, crude fibre, ash content, moisture content and lipids in a completely randomised design. The cultured samples were obtained from Keemtech Farm Limited Mando Kaduna, Kaduna State and wild samples from Galma River Zaria, Kaduna State. Data collected was subjected to independent T-test for significant difference among treatments. The crude protein content of cultured and wild *H. longifilis* were 73.61 ± 5.19 and 69.93 ± 9.91 respectively which showed significant difference ($p \leq 0.05$). There was no significant difference ($p \leq 0.05$) in lipid values of cultured and wild *H. longifilis* (16.11 ± 4.96 and 17.09 ± 0.96). The lipid values were higher in the wild when compared to the cultured. The ash value was 5.81 ± 0.92 for cultured and 7.07 ± 0.60 for wild. The proximate composition of wild and cultured *H. longifilis* in this study showed significant difference in dry matter and protein with no significant differences in lipid, ash and crude fibre.

Keywords: Cultured, *Heterobranchus longifilis*, Proximate composition, Wild

Introduction

Fish is a good source of quality protein and an excellent source essential amino acids in the proportion required for good nutrition. Fish provides about 40 % of the total supply of protein available to Nigerians (World fish center, 2018). Fish protein compares very well with egg, milk and meat. It is also rich in vitamins, minerals and polyunsaturated fatty acids which may help to decrease heart related diseases, fish is known to contain micronutrients, such as iron, iodine, zinc, vitamin A and B (World Fish Centre, 2005). Fish and fishery products supplement the predominantly carbohydrate-based diet of many people in Nigeria (Keremah and Amakiri, 2013). The health and nutritional status of young children, pregnant and lactating women are affected positively through the consumption of fish (WHO/FAO/UNU (2007)). As the global population continues to grow there is an increased demand for fish and fishery products. Aquaculture production remains the best option to meet this growing demand (WorldFish, 2018). Currently, Nigeria produces over one million metric tons of fish and has a fish demand of about 2 million metric tons (WorldFish, 2018). There is therefore the need to make good quality fish available to the teeming population.

Proximate analysis is usually used to evaluate the amounts of protein, lipid, water, ash and carbohydrate in an organism. This evaluation is often necessary to make sure that each food item such as fish meet dietary standards (Onyia, *et al.*, 2013). It has been documented that chemical composition varies widely, therefore the awareness of the proximate composition of fish will enhance its utilization (Onyia, *et al.*, 2013). Fagbenro, *et al.* (2005) examined the proximate composition of four commercial West African important species while (Udo, 2012) studied the composition of *Heterobranchus longifilis*, *Clarias gariepinus* and *Chrysichthys nigrodigitatus*. The nutrient values of wild and cultured *Heterobranchus bidorsalis* and *Clarias gariepinus* was compared by Onyia, *et al.* (2013) and Obaroh, *et al.* (2015).

Heterobranchus longifilis, a freshwater Clariid catfish is an important aquaculture species in Nigeria and can use supplementary feed (Ayinla, 2007). This fish grows fast, can tolerate overcrowding and commands high market value (Keremah and Alfred-Ockiya, 2013). The aim of this study is to compare the proximate composition of wild and cultured *H. longifilis* with the view to explore its nutritional value.

Materials and Methods**Fish Sample Collection and Preparation**

A total of 20 samples of table size *Heterobranchus longifilis* was used for the study. Ten *H. longifilis* was obtained from Galma River (wild) Zaria, Kaduna State. After which another ten *H. longifilis* was purchased from Keemtech

Farm Limited, Mando Kaduna, Kaduna State and was labelled cultured. The fishes ranged between 395-912g and were transported in 500 litres Jerry can to the fisheries unit College of Agriculture and Animal Science, Mando road, Kaduna state. The fish samples were weighed with a weighing scale, degutted and cleaned with water. Specimens were packaged in separate labelled polythene bags and frozen at an average temperature of 4°C in readiness for analysis.

Proximate Analysis

The crude protein, crude fibre, ash content, moisture content and lipid of the fish samples was carried out according to the procedures of AOAC (1990). All proximate components were analyzed in triplicate and reported as mean on dry matter basis. The analysis of the samples was carried out at National Animal Production Research Institute Zaria.

Statistical analysis

Data collected was subjected to Prism graph pads version 8 and independent T-test for significant difference among treatments using SPSS version 25. The level of significance set for treatments was $P \leq 0.05$.

Results

Table 1 and Figure 1 shows the proximate composition of *Heterobranchus longifilis* from the cultured and wild sources. The dry matter was significantly higher in cultured with least values obtained in wild *Heterobranchus longifilis*. The crude protein value was higher in the cultured (76.61±5.19%) than in the wild fish which was (63.93±9.91%). While the lipid value for the wild *H. longifilis* (17.09±4.96%) was higher than the (16.11±0.96%) recorded for the cultured. The ash percentage was higher in the wild fish (7.07±0.60%) than the cultured fish (5.81±0.92%). The crude fiber followed the same trend, it was higher in the wild fish (0.83±0.73%) than the cultured fish (0.76±0.18%). However, the lipid, ash and crude fiber values showed no significant difference ($p \leq 0.05$).

Table 1: Proximate composition of *Heterobranchus longifilis* from the cultured and wild sources.

Sample (%)	Dry Matter	Crude Protein	Lipid	Ash	Fiber	Moisture
Cultured	95.62±3.22 ^a	73.61±5.19 ^a	16.11±4.96 ^a	5.81±0.92 ^a	0.76±0.18 ^a	4.91±1.78 ^a
Wild	92.81±3.73 ^b	69.93±9.91 ^b	17.09±0.96 ^a	7.07±0.60 ^a	0.83±0.73 ^a	6.85±1.63 ^a

Means with the same superscript in the same column are not significantly different ($p \leq 0.05$).

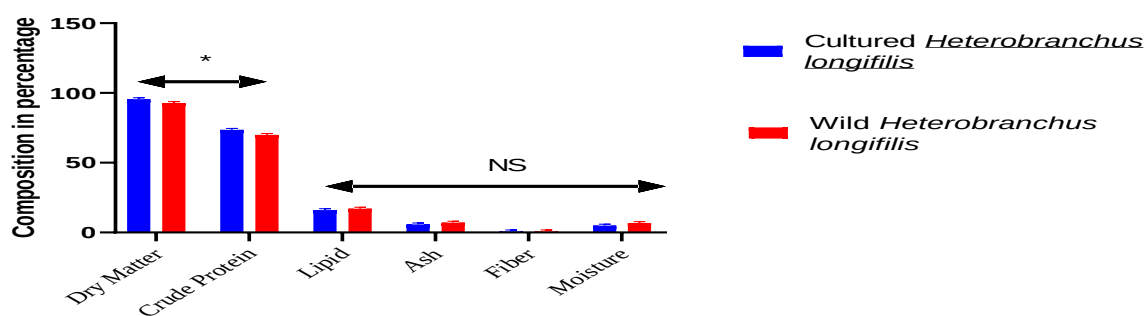


Figure 1: Proximate composition of *Heterobranchus longifilis* from the cultured and wild sources.

* = Significant NS= No significant

Discussion

The proximate composition of *H. longifilis* from the wild and culture was close to the limits reported for *Heterobranchus* species by Fabenro *et al.* (2005) and Olaniyi *et al.* (2016). These authors reported crude protein values of 69.30±0.27 and 66.79±2.91 respectively. However, the crude protein level obtained in this study was higher when compared to the 55.03±6.21 obtained in wild *H. bidorsalis* by Onyia *et al.* (2013) and 59.8 ± 0.5 for *H. longifilis* by Koumi *et al.* (2011). The high protein content reveals that *H. longifilis* is a good source of quality protein (WHO/FAO/UNU, 2007). The variation in crude protein of cultured and wild *Heterobranchus longifilis* could be due

to the nutritional status of the diet fed to them which is in line with the findings of Fabenro *et al.* (2005) who stated that higher crude protein value in the culture could be as a result of the compounded feed being supplied and noted that body composition is influenced by nutritional history. The variation in crude protein between the cultured and the wild could also be as a result of essential nutrients in the local environment of the fish (Onyia *et al.*, 2013). The lipid was within the range reported for *Heterobranchus* species by Fabenro *et al.* (2005) and Udo (2012). The higher lipid content in wild when compared with the cultured fish was contrary to the result of Onyia *et al.* (2013) for *H. bidorsalis*. Keremah and Amakiri (2013) stated that the fat content in an animal's body is highly variable. Variation in ash values between the wild and cultured *H. longifilis* could be based on nutritional and environmental factors. However, this ash value was within normal range reported for *Heterobranchus* species by Fabenro *et al.* (2005) and Udo (2012). It has been documented that proximate composition varies with geographical location, season of the year, feed intake, metabolic efficiency, energy expelled by the fish, sex, species of fish and size (Keremah and Amakiri, 2013).

Conclusion

This study revealed the importance of *H. longifilis* as a good source of protein and other nutrients. The proximate composition of *H. longifilis* from wild and cultured in this study showed significant difference in dry matter and protein with no significant differences in lipid, ash and crude fibre.

References

- A.O.A.C. (1990). Official Methods of Analysis. Association of Official Analytical Chemistry vol.13 Washington, USA pp. 1234.
- Ayinla, O.A. (2007). Analysis of feeds and fertilizers for sustainable aquaculture development in Nigeria. In: Hasan *et al.* (Eds) Study and Analysis of Feeds and Fertilizers for Sustainable Aquaculture Development, FAO Fisheries Technical Paper, No 497 pp. 453-470.
- Fagbenro, O. A., Akinbulumo, M. O., Adeparusi, O. E. and Raji, A. A. (2005). Flesh Yield, Waste Yield, Proximate and Mineral Composition of Four Commercial West African Freshwater Food Fishes. *Journal of Animal and Veterinary Advances*, 4(10):848-851
- Keremah R. I. and Amakiri G. (2013). Proximate composition of nutrients in fresh adult catfishes: *Chrysichthys nigrodigitatus*, *Heterobranchus bidorsalis* and *Clarias gariepinus* in Yenagoa. *Nigeria Greener Journal of Agricultural Sciences*, 3(4): 291-294
- Keremah R. I. and Alfred-Ockiya J F. (2013). Effects of dietary protein level on growth and body composition of mudfish, *Heterobranchus longifilis* fingerlings. *African Journal of Biotechnology*, 12(9): 971-975
- Koumi, A.R., Koffi, K.M., Atse, C.B. and Kouame, P.L. (2011). Growth, feed efficiency and carcass mineral composition of *Heterobranchus longifilis*, *Oreochromis niloticus* and *Sarotherodon melanotheron* juveniles fed different dietary levels of soybean meal based diets. *African Journal of Biotechnology*, 10(66): 14990-14998.
- Obaroh, I. O., Haruna, M. A. and Ojibo, A. (2015). Comparative Study on Proximate and Mineral Element Composition of *Clarias gariepinus* from the Cultured and Wild Sources. *European Journal of Basic and Applied Sciences*, 2(2): 19-26
- Olaniyi, W.A., Makinde, O. A. and Omitogun, O. G. (2016). Comparison of proximate composition and sensory attributes of Clariid catfish species of *Clarias gariepinus*, *Heterobranchus bidorsalis*, and their hybrids. *Food Science and Nutrition*, 5(2): 285-291
- Onyia, L. U., Michael, K.S., Manu, J.M. and Sabo, M. (2013). Comparison of Nutrient Values of Wild and Cultured *Heterobranchus bidorsalis* and *Clarias gariepinus*. *Nigerian Journal of Fisheries and Aquaculture* 1(1): 7 – 12.
- Udo, P. J. (2012). Investigation of the Biochemical Composition of *Heterobranchus longifilis*, *Clarias gariepinus* and *Chrysichthys nigrodigitatus* of the Cross River, Nigeria. *Pakistan Journal of Nutrition*, 11(10): 963-966
- WHO/FAO/UNU (2007). Protein and Amino Acid Requirements in Human Nutrition; Report of a joint WHO/FAO/UNU Expert Consultation, WHO Tech Rep Ser No 93 Geneva
- World Fish Centre (2005). Fish for All: Turning point for Aquaculture and Fisheries in Africa, 28(3 and 4):14 – 20.
- Zenebe, J. Ahlgren, G. and Boberg,
- WorldFish (2018). WorldFish Nigeria Strategy: 2018-2022. Penang, Malaysia: WorldFish.
- Strategy: 2018-09 World fish center (2018) Nigeria
- <https://www.worldfishcenter.org/where-we-work/africa/nigeria> assessed 07/15/2021

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Evaluation of Chemical Quality Changes in Frozen *Gadus morhua* Available in Markets of Imo State, Nigeria

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Abstract

A total of forty (40) frozen *Gadus morhua* obtained from cold room and open markets of Ohaji, IsialaMbano and Mbaitoli LGA representing the three zones of Imo State were evaluated for quality changes in their chemical composition with regards to their value changes in AMM, TVB-N, TMA-N, AV, FFA, and pH at the hands of the final consumers. Results were analysed using a one way analysis of variance employing SPSS package and compared using the Duncan multiple range test which indicated a significant difference in AMM- ammonia, TMA-N- Trimethylamine – Nitrogen, TVB-N- Total volatile base Nitrogen, AV- acid value and FFA- Free fatty Acid at $p \leq 0.05$ with p-values of 0.00, 0.00, 0.00, 0.00 and 0.02 respectively while pH values remained insignificantly different at p-value of 1.00. During the fish storage in ice, volatile compounds such as ammonia (NH_3) and trimethylamine (TMA), are produced by autolytic and bacterial processes, resulting in an ammoniacal and strong fish odour, typical of deteriorated fish. These parameters generally are indicators of fish spoilage. Significant rise in Ammonia value from 15.65 ± 0.04 for cold room samples to 20.96 ± 0.78 from an open market in Ohaji LGA and TMA-N cold room values of 2.46 ± 0.39 to 3.95 ± 0.45 from an open market indicating fast rate of spoilage which is concluded to be due to the unsafe exposure of fish and its handling after it must have left the cold rooms. Even though the values obtained in open markets did not exceed the acceptable limit of freshness, quality loss was significantly observed. It is recommended that sanitary and food inspection agencies resume function in our markets to reduce the risk of fish contamination which subsequently reduces its quality.

Key words; Chemical quality, Cold room, Open markets, Frozen *Gadus morhua*, Spoilage

Introduction

Fish freshness refers to the maintenance of sensory, chemical and nutritional characteristics the fish possess at capture after a time period. Alteration of this freshness begins immediately after capture as a result of enzymatic, bacterial and oxidative activity on fish, a state that can be averted by exposing the fish to a form of preservation and on time. In Nigeria, species of fish commonly imported are many with cod (*Gadus morhua*) constituting one of the majority (Agom *et al.*, 2012). According to the report of Oloalu, (2016), most fish stock come from Port Harcourt and Lagos with wholesalers transporting their goods in refrigerated trucks to cold rooms while retailers use cabs, motorcycles and head load to transport the frozen fish where they are supplied directly to people, hawked publicly, sold on the road side or in stalls of fish markets. Methods employed by retailers to attract customers such as conspicuous display of frozen fish (Olaolu, 2016) can lead to sediment and bacterial accumulation on fish. Fresh fish have been reported by Nwazuo *et al.*, (2016) to be exposed readily to high contamination leading to openings for microbial invasion; inadvertently leading to changes in chemical quality. During the fish storage, volatile compounds such as ammonia (NH_3) and trimethylamine (TMA), are produced by autolytic and bacterial processes, resulting in an ammoniacal and strong fish odor, typical of deteriorated fish. TMA results from the bacterial reduction of trimethylamine oxide (TMAO), which occurs naturally in the marine organisms to allow osmotic regulation. Chemical changes can be as a result of the presence of TVBN, Histamine, heavy metals, pesticide residues and nitrates (Olaolu, 2016). The pH determination of the fish stored allows the identification of glycolysis phenomena through its reduction in post-mortem fish, and subsequent increase to values above 7, due to the production of volatile compounds, which indicates advanced decomposition. World Bank, (2013) has predicted a rapid population growth, estimated at 2.3 per cent annually during the 2010 - 2030 period, which will lead to total food fish consumption demand substantially rising - by 30% between 2010 and 2030. South-east Nigeria is a region highly populated with persons who have more preference for fish flesh to beef (Emere and Dibal, 2013), in fact, several diets consumed within its locality includes fish in its various forms. As a result of recent development in Nigeria, beef has become an expensive commodity due to the farmer's herdsman clash. At this rate of consumption and with the need to avert

consequential effects of consuming non-safe fish of low nutritional value this research will throw light on the chemical quality of fish available to end users, one that shows the level of bacterial and enzymatic activity on fish.

Materials and Methods

Fish identification, transportation and chemical procedures

The fishes were identified with the aid of standard fish identification keys by Reed *et al.*, (1967), Loveque *et al.*, (1991) and FAO (1990) Field identification Guide to the commercial marine resources of the Gulf of Guinea. The length, weight and temperature of the fish samples were recorded and the fish carefully put in well labelled sterile polyethylene bags, stocked inside iced boxes (containing ice blocks to maintain temperatures close to that of the cold rooms) and quickly transported to the laboratory for analysis. The chemical analysis was carried out using the recommended standard methods (AOAC, 2005) and results were compared with one way analysis of variance (ANOVA) as described by Njoku *et al.*, (1998). The observed significant difference in mean values of treatments was then separated using the Duncan's multiple range test (Duncan, 1955) employing the computer statistical package for Social Sciences (SPSS) version 19 window 7.

Results

Results from table 1 shows significant difference across values for AMM, TVB-N, TMA-N, AV and FFA in samples from cold room and open markets. The pH on the other hand reflected a non-significant difference as it presented a P-value of 1.000. Ammonia indices ranged from 15.65 ± 0.04 to 20.96 ± 0.78 with the least value from cold room samples and the highest value emanating from open markets of Ohaji L.G.A. TVB-N, TMA-N, AV, and FFA values ranged from 11.32 ± 0.04 to 17.42 ± 0.40 , 2.46 ± 0.39 to 3.98 ± 0.49 , 3.09 ± 0.27 to 5.07 ± 0.31 and 1.54 ± 0.19 to 2.48 ± 0.22 respectively all of which had their least values from cold room samples and highest values from Ohaji open market with the exception of the TVB-N index which is from the open market of Mbaitoli LGA. On the contrary, lowest value for pH was obtained from the open markets of Ohaji LGA (6.00 ± 0.22) while the highest value was obtained for the cold room samples (6.58 ± 0.50). Comparison for chemical indices are shown in fig. 1 where from observation, AMM had highest values across all parameters considered whereas FFA had the least.

Discussion

In present times the importance of fish having being largely associated with being readily available as a good source of protein (Adebayo-Tayo *et al.*, 2012; Suleiman *et al.*, 2014), has been an answer to the food need of every class of persons, rich or poor, sick or healthy due to its portability and ability to be preserved in different forms wholly or filleted. The quality of frozen products is closely related with the quality of initial fresh fish, freezing settings and thawing conditions due to their influence on chemical reactions and muscle degradation. The determination of TVBN considers all volatile nitrogen compounds in the sample like ammonia (NH_3), Trimethylamine (TMA), and Dimethylamine Acid (DMA) levels to assess the fish freshness as they increase with fish deterioration (Senapati and Sahu, 2020).

The data in table 1 shows obvious difference in chemical properties of the fishes obtained from cold room and various open markets. Statistically, parameters of AMM, TVB-N, TMA-N, AV and FFA were significantly different at $p > 0.05$. Ammonia indices rose to 20.39 ± 0.52 in samples from open markets of Ohaji, 19.94 ± 0.35 in open market samples of IsialaMbano and 19.42 ± 0.34 in open market samples of Mbaitoli as against 15.65 ± 0.16 value of the cold room samples. FAO (1994) opined that volatile amines such as ammonia and small amount of monomethylamine and dimethylamine are produced as bacteria grow on surface of fish tissue-parameters that are general indicators of fish spoilage. TVB-N cannot entirely be used as fish freshness indicator (Castro *et al.*, 2006) in stored frozen fish however, the values increases rapidly as temperature increases ($> 37^\circ\text{C}$) within 24 hours in marine fish. Deamination of ammonia and formation of other volatile amines causes the increase in TVB-N, as gradual rise in TVB-N values is recorded even in the absence of Trimethylamine oxide (Sikorski and Kostuch, 2003). Roiha, *et al.*, (2018) in their experiment observed that TVB-N values for *Gadus morhua* increased from 12.5 ± 2.3 to 18.8 ± 12.9 . In addition, Popelka *et al.*, (2016), showed that TVB-N values from fresh samples were significantly different from frozen samples over a period of time. This opinion is in tandem with the result of this research revealing that samples in cold rooms were of good biochemical quality which progressively reduced as they enter the open markets. TVB-N values that reach 30mg/100g for any fish would be considered stale while levels of 40mg/100g is unfit for human consumption as proposed by Codex

Alimentarius Committee in 1968 and reported by Steel *et al.*, (1996). All results gotten on TVB-N satisfied this mark and can be said to be fresh as the highest values recorded for was 17.42 ± 0.40 and is in agreement with results of Khidhir *et al.*, (2013) who confirmed that some frozen fish imported and sold in Sulaimani markets are considered fresh. Production of TMA-N is slow at the start of chemical change in fish and gradually increases exponentially in pace after few days in chilled storage. According to Avramiuc, (2017), 0-1 mg/100g TMA indicates fresh fish, 1-5mg/100g indicates relatively fresh fish while values above 5mg/100g indicates altered fish –gross spoilage. Muzaddadi (2016), reported TMA-N values of 1.25-2.00mg/100g as acceptable limits and 10- 15mg/100g limits above which chilled fish becomes unfit for consumption. This research result reported highest TMA-N values of 3.98mg/100g which falls within the limit of acceptance according to Avramiuc, (2017) and Muzaddadi (2016). The results from this research indicates that samples of cold room are of good quality-one which depreciates as fish enter into the open market thus assumed relatively fresh. It is however noted that TMA values will vary depending on type of fish, storage condition, temperature and handling. FFA is a measure of the hydrolysis of lipid by that causes hydrolytic rancidity (Farzana *et al.*, 2014). Open market values for Acid value (AV) and Free Fatty Acid (FFA) were significantly different to those obtained from the cold room at $p > 0.05$. Acid values ranged between 3.09 ± 0.33 for cold room to 5.02 ± 0.05 for open markets. Consequently, FFA values ranged from 1.54 ± 0.12 for cold room to open market values of 2.46 ± 0.02 from Ohaji. Generally, marked increase in values of AV and FFA from cold room to open market is an indication of deteriorating quality of fish. Fish contain large proportion of highly unsaturated fat which vary in quantity with species. Fatty species as Mackerel have high lipid content, free fat content and proportion of triglycerides while lean species as cod have low lipid content basically in the form of phospholipids and lipoproteins (FAO, 1994). Sikorski and Kolakowska (1994) proposes more pronounced oxidation as a result of protein denaturation especially in lean fish species (Natsebaet *et al.*, 2005). This explains the higher values of FFA in *Gadus morhua* (a lean fish). FFA content shows a possible increase of enzymatic activity due to temperature fluctuation, as lipid deterioration cannot be inhibited in proper conditions after damage has been done. Afugbuom (2016) in his work reported similarly for AV and FFA revealing a mean difference that is statistically significant at $p > 0.05$. Both work showed higher values for fishes in the open market compared to that in the cold room. An increase in FFA value from 3.2 to 5.66 was recorded by Nazemroayaet *et al.*, 2009 at $p \leq 0.01$, indicative of extensive hydrolysis of lipids after a period of frozen storage. Okeoyo, *et al.*, (2009) reported that the lower the pH of fish flesh, the slower the growth of bacteria and vice versa. As bacteria produce acid during carbohydrate decomposition, the acidity rises, also indicative of bacterial presence (Eyo 1993). Results revealed that there is no statistical significant difference in values of pH across the local governments on fish experimented. Monteiro (2019), in his study observed that pH of Cod and Mackerel were quite neutral. Despite the insignificant difference obtained statistically, there is a marked reduction in pH values from cold rooms to open markets. This indicates that acidity levels rose as the fish is exposed to open market conditions. This marked difference is not farfetched from the fact that microbial presence has considerably increased and deterioration process had set in. The findings of Taşkaya *et al.*, (2003) recorded a pH range of 6.83 – 7.03 for fresh fish which gradually reduced to between 5.67 – 5.82 after storage, indicative of start of deteriorating process although Aubourget *et al.*, (2004) asserted that during frozen storage, there is no significant difference in pH values. This result of this research is in tandem with Afugbuom, (2016) who reported that pH values between cold room samples and open market samples showed no significant difference at $p > 0.05$.

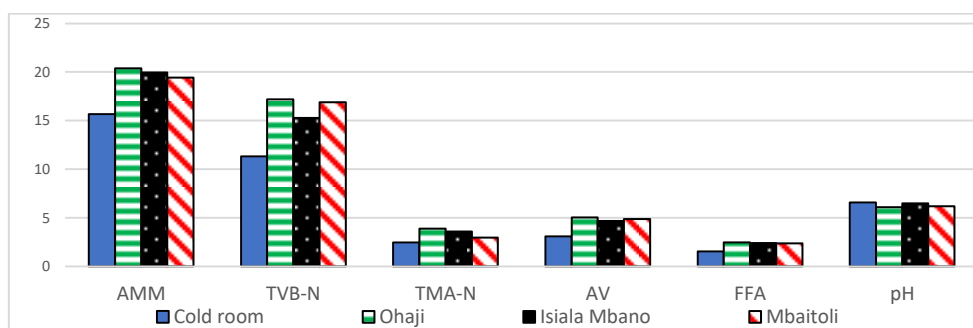
Conclusion

Temperature fluctuations are the most significant factors in maintaining quality through the distribution chain. Chemical, biochemical and physical inevitable and irreversible processes still occur during frozen storage but at a slow rate. If subject to poor handling in connection with freezing and cold storage, the product will be ruined. Difference in chemical quality of fresh and thawed fish may be negligible if fish is handled with care during and after catching, frozen as quickly as possible and stored at a stable temperature of 30°C (or below). This however is almost impossible with the handling habits found in our markets. Handlers and traders act as they deem fit depending on the limited resources available to them and market place involved. Right at the market stand, fish are exposed to dust, rough handling, flies, and other environmental contaminants thus increasing the microbial and in turn, the chemical changes noticed in open market samples. Because frozen fish is exposed to large variations of temperature fluctuations, during storage and transport, short-term storage of the raw material, gentle processing, quick freezing, short-term storage as a semiprocessed product, and short-term cold storage at temperatures lower than 30°C, will result in the best product. It is recommended that safe presentation at cold rooms and open market practice should be upheld since chemical changes is an indication of microbial presence in the fish.

Table 1 Results of chemical analysis for *GadusMorhua* collected from sampled areas

Paramaters/ Place of collection	Cold room	Ohaji	IsialaMbano			Mbaitoli			P-value		
		IO1	IO2	IO3	AO1	AO2	AO3	AnO1	AnO2	AnO3	
AC											
mgNH ₃ /100g AMM	15.65 [±] 0.04	20.96 [±] 0.78	19.70 [±] 0.25	20.52 [±] 0.29	20.34 [±] 0.26	20.00 [±] 0.65	19.48 [±] 0.34	19.13 [±] 0.67	19.24 [±] 0.39	19.89 [±] 0.58	.000
mg/100g TVB-N	11.32 [±] 0.04	17.16 [±] 0.99	17.13 [±] 0.34	17.22 [±] 0.22	15.03 [±] 0.19	15.74 [±] 0.36	15.06 [±] 0.28	16.23 [±] 0.27	17.01 [±] 0.22	17.42 [±] 0.40	.000
mg/100g TMA-N	2.46 [±] 0.39	3.95 [±] 0.45	3.98 [±] 0.49	3.68 [±] 0.20	3.88 [±] 0.24	2.99 [±] 0.30	3.86 [±] 0.21	2.87 [±] 0.42 ^a	3.00 [±] 0.39	3.02 [±] 0.21	.000
%Oleic Acid AV	3.09 [±] 0.27	5.03 [±] 0.21	5.07 [±] 0.31	4.96 [±] 0.12	4.78 [±] 0.45	4.605 [±] 0.32	4.53 [±] 0.35	4.84 [±] 0.38	4.71 [±] 0.24	5.0 [±] 0.34	.000
mgKOH/g FFA	1.54 [±] 0.19	2.47 [±] 0.09	2.48 [±] 0.22	2.44 [±] 0.32	2.39 [±] 0.36	2.42 [±] 0.17	2.37 [±] 0.32	2.30 [±] 0.45	2.42 [±] 0.17	2.39 [±] 0.24	.002
PH	6.58 [±] 2.41	6.00 [±] 1.77 ^a	6.00 [±] 1.63 ^b	6.03 [±] 1.83 ^c	6.51 [±] 1.89 ^d	6.52 [±] 2.08 ^e	6.41 [±] 2.17 ^f	6.02 [±] 1.99 ^g	6.32 [±] 1.92 ^h	6.24 [±] 1.76 ⁱ	1.00 0

Where; AMM- ammonia, TMA-N- Trimethylamine – Nitrogen, TVB-N- Total volatile base Nitrogen, AV- acid value, FFA- Free fatty Acid and pH- Acidity or Basicity. Figures in each row with superscript are not significantly different at $p > 0.05$. Figures in row without superscript are significantly different at $p < 0.05$.

**Fig 1; Graph showing relationship of chemical indices for cold room and open market *Gadusmorhuasamples* in Imo state**

References

- Adebayo-Tayo B. C., Odu N. N., Anyamele L. M., Igwiloh N. J. P. N. and Okonko I. O. (2012). Microbial Quality Of Frozen Fish Sold In Uyo Metropolis. *Nature and Science*; 10(3): 71-77.
- Afugbuom, E. C. (2016). Microbiological Analysis, Sensory Evaluation and Biochemical Sefety of selected Frozen Fish in Onitsha Markets, Anambra State, Nigeria. An unpublished thesis submitted to the postgraduate school, Federal University of Technology Owerri, Nigeria.
- Agom, D. I., Etim, G. C. & Etuk, E. A., (2012). Analysis of wholesale frozen fish markets in Calabar, Cross River State, Nigeria. *Trends in Agricultural Economics*, 5(2): 61-69. Doi:10.3923/tae.2012.61.69
- AOAC (2005). *Official methods of Analysis of the Association of Official Analytical Chemists* (18thed), Mary land, USA, 1550
- Aubourg S. P., Pineiro C., Gonzalez M. J. (2004). Quality loss related to rancidity development during frozen storage of horse mackerel (*Trachurus trachurus*). *J. Amer Oil Chemi Society*. 81(7): 671-678.
- Avramiuc, M. (2017). The influence of slow thawing on evolution of some biochemical compounds in frozen fishes. *Food Environ. Saf. J.* 16, 92–97.
- Castro P, Carlos P. P. J, Caballero C. M, Sanjuan Velazques E, Millan De Larriva R. (2006). Total volatile base nitrogen and its use to assess freshness in European sea bass stored in ice. *Food Control* 17:245-8.
- Duncan, D.B. (1955). Multiple range and multiple F test. *Biometrics* 11: 1-42.

- Emere, M. C. & Dibal D. M. (2013). A Survey of the Methods of Fish Processing and Preservation Employed By Artisanal Fishermen in Kaduna City. *Food Science and Quality Management*. 11(16):16-22.
- Eyo AA (1993). Traditional and Improved Fish Handling, Preservation and Processing Techniques. Paper Presented At National Workshop On Fish Processing Storage, Marketing And Utilization. Company, Philadelphia London. 138:148 - 150, 164.
- Food and Agriculture Organization (FAO), (1994). *Freezing and refrigerated storage in fisheries*. Fisheries technical paper-340.
- Food and Agriculture Organization (FAO), (1990). *Field guide to commercial marine resources of the Gulf of Guinea* RAFR/014/F1/90/02.
- Khidhir, Z.K., Murad H. O. M. and Arif E.D. (2013). Qualitative assessment of imported frozen fish fillets in Sulaimani markets. *Iraqi Journal of Veterinary Sciences*, 27(1):49-55
- Loveque, C. Pyugy, O. & Tengel G. G., (1991). The fresh and brackish water fishes of West Africa. Vol.1. Musu Royale de 1. *Afrique Centrale*, Tervurem, Belegigue Edition de. 1. ORSTOM. 384pp.
- Monteiro, K. (2019). Analysing physical-chemical parameters for processing dried mackerel and cod products for Cabo Verde. United Nations University Fisheries Training Programme, Iceland. Final project. Available at <http://www.unuftp.is/static/fellows/document/katia18prf.pdf>.
- Natseba A, Lwalinda I, Kakura E, Muyanja CK, Muyonga JH. (2005). Effect of pre-freezing icing duration on quality changes in frozen Nile perch (*Lates niloticus*). *Food Res Int*; 38: 469-74.
- Nazemoroaya S., Sahari M. A. and Rezaei M. (2009). Effect of Frozen Storage on Fatty acid Composition and Chenges in Lipid content of *Scomberomorus commersoni* and *Carcharhinus dussumieri*. *Journal of Applied Ichthyology* 25:91-95
- Njoku D. C., Onuh M. O. & Ohazurike N. C, (1998). *Research methods and field Experimentation in Agriculture and Biological Sciences*. Alphabet Nigeria publishers Ltd. Owerri, Nigeria. 111pp
- Nwazuo N.I, Keke I.R, Egeruoh A.S, Nwanjo S.O and Ugoeze Q.C (2016) Sanitation and Handling during Processing of Fish in Oguta Fishing Communities and Its Economic Implications. *International Journal of Scientific & Engineering Research*, 7, (5):123-130..
- Okeoyo, G.O., Lokuruka, M.N.I., Matofari, J.W. (2009). Nutritional composition and shelflife of the lake Victorian Nlie perch (*Lates niloticus*) stored in ice African Journal of Food, Agriculture, Nutrition and Development, 9(3), 901-919
- Olaolu, O. F., (2016). *Assessment of quality and handling procedures of imported frozen fish in Oyo State, Nigeria*. A thesis in the department of Aquaculture and Fisheries Management in partial fulfillment of the requirement for the degree of Doctor of Philosophy, University of Ibadan.
- Popelka, P.; Jevinova, P.; Marcincák, S. (2016). Microbiological and chemical quality of fresh and frozen whole trout and trout fillets. *Potravin. Slovak J. Food Sci.*, 10, 431–436.
- Reed, W., Burchard, J., Hopson, A. J., Jennes, J. & Yaro, I., (1967). *Fish and Fisheries of Northern Nigeria*. Ministry of Agriculture, Northern Nigeria, Zaira.
- Roiha, I.S.; Tveit, G.M.; Backi, C.J.; Jónsson, Á.; Karlsdóttir, M.; Lunestad, B.T. (2018). Effects of controlled thawing media temperatures on quality and safety of pre-rigor frozen Atlantic cod (*Gadus morhua*). *LWT Food Sci. Technol.* 90, 138–144.
- Senapati, M. and Sahu, P.P. (2020). Onsite fish quality monitoring using ultra-sensitive patch electrode capacitive sensor at room temperature. *Biosens. Bioelectron.* 168, 112570.
- Sikorsky, ZE, and A Kolakowska. 1994. Changes in proteins in frozen stored fish. In: *Seafood Protein*, edited by Sikorski, ZE, Pan, BS, Shahidi, F. Chapman & Hall, Inc., pp. 99–117.
- Sikorski Z, and Kostuch S. (2003). Trimethylamin N-oxide demethylase: Its occurrence, properties, and role in technological changes in frozen fish. *LWT*; 31: 213-9.
- Steel RGD, Torrie JH, Dickey DA. (1996). Principles and procedures of statistics. A biometrical approach. 3rd ed. McGraw Hill Book Company Inc, New York, USA.
- Suleiman A.M.E., Hassan Z.M.A., and Elkhailifa E.A. (2014). Microbial safety of dried fish meat (kejeik) produced in Sudan. *Food Nutr. Sci.*, 5: 606-6613
- Taşkaya L, Çakli S, Kışla D, Kilinç B. (2003). Quality changes of fish burger from rainbow trout during refrigerated storage. *J Fisher Aquatic Sci.* 20:147-154.
- World Bank, (2013). *World development indicators: Nigeria*. Retrieved from <http://data.worldbank.org/country/Nigeria>

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Proximate Composition of Nile Tilapia (*Oreochromis niloticus*) Cultured in fibre Tank and Earthen Pond

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Abstract

The aim of the study was to evaluate and compare the proximate composition of Nile Tilapia (*Oreochromis niloticus*) cultured in a fibre tank using treated water and the fish cultured in an earthen pond. Five fish (250±22.41g) from each culture systems were collected differently into containers. The fish samples were prepared in the laboratory by removing all the bones and viscera and other parts were dried at 105⁰C and analyzed for proximate composition and water samples were also analyzed for physiochemical parameters using a combined digital YSI meter Model 57 and thermometer for the temperature. Analyses showed that the temperature, dissolved oxygen (DO) and Nitrate were not significantly different ($P>0.05$) from each other but the water pH, ammonia (NH₃) and Nitrite were significantly different ($P<0.05$) from each other. Analyses showed that the crude protein value recorded in the fish cultured in the tank was higher (32.01±0.11) than the value recorded in the fish cultured in the pond (28.87±0.41) and was therefore significantly different from each other ($P>0.05$). Analyses also showed that there were significant differences ($P>0.05$) in the ether extract, ash and moisture content obtained in the fish cultured in both culture systems. Therefore, the study concluded that *Oreochromis niloticus* from both culture systems was an adequate dietary source of protein and other nutrients which are similar to other sea and fresh water fishes.

Keywords: Proximate composition, *Oreochromis niloticus*, fibre tank, earthen pond

Introduction

Nutritionally, fin fish and shell fish have been reported to be widely accepted as a good sources of animal protein and other elements for the maintenance of a healthy body (Dereset *et al.*, 2019). According to Arannilewaet *et al.* (2005), fish has been reported to play a major role in alleviating mal-nutrition most especially in young children, pregnant women and the old because of the high protein content, polyunsaturated fats, vitamins and minerals. *Oreochromis niloticus* is the most widely cultured fish among the tilapias (Mary *et al.*, 2014). It has been reported by several authors to have an efficient feed conversion ratio, demonstrates fast growth rate and has a high tolerance to low water quality, ease of spawning and resistance to disease (Mary *et al.*, 2014). Generally, the quality of fish has been reported by Floset *et al.* (2002) to be affected by exogenous and endogenous factors. Exogenous factors were therefore classified as diet composition, feeding frequency and fish environmental parameters such as salinity, pH and temperature while endogenous factors are genetic and life stage, age, size, sex and anatomical position in the fish (El-Zaeem *et al.*, 2012). Data concerning the chemical composition of fish has been reported to provide information on nutritious healthy foods of low fat and high protein content (Foranet *et al.*, 2005). Fanuelet *et al.* (2017) reported that the study of the chemical composition of fish is also important in keeping the quality and technological characteristics of fish. Measurement of proximate profiles such as protein, lipids and moisture content is often necessary to ensure that they meet the requirement of food regulations and commercial specifications (Fanuelet *et al.*, 2017). Zenebeet *et al.* (1998) reported that the nutritional composition of freshwater fish was found to differ between geographical localities. The present study aimed to determine and compare the proximate composition of *Oreochromis niloticus* cultured in two different culture systems.

Materials and Method

Collection of Water and Fish

Fish and water samples were collected on the same day at Badore Research Centre, Nigerian Institute for Oceanography and Marine Research (NIOMR). The water temperatures were recorded immediately using mercury in glass thermometer and the water samples were collected from both culture systems (pond and fibre tank) into sterile sample bottles and transported to the laboratory for analysis. A total of 10 fish (250±22.41g) comprising of five each from the culture systems (pond and fibre tank) were collected into two different containers.

Water Quality Analysis

The water samples were analysed at the Department of Biochemistry, Lagos State University Teaching Hospital for dissolved Oxygen (DO), pH, Salinity, Conductivity, Nitrate, Nitrite and Ammonia (NH₃) using the standard method for fresh water analysis as described by Fanuel Jim *et al.* (2016).

Preparation and Proximate Analysis of Fish Samples

The fish samples were prepared in the laboratory by removing all the bones and viscera and then discarded and were oven-dried at 105°C, cooled and ground into fine powder. The proximate analysis was carried out at the Department of Biochemistry, Lagos, University Teaching Hospital according to the standard method described (A. O.A.C, 2000). The following nutrients were analysed: crude protein (CP), Ether Extract (EE), moisture content and crude fibre (CF). Crude protein was determined using Kjeldahl method that involved three steps which are digestion, distillation and titration. A known weight of the dried sample was digested using concentrated sulphuric acid and copper sulphate as catalysts. The digested and diluted sample solution were neutralized and distilled using 40% sodium hydroxide and boric acid and the distillate was then titrated using sulphuric acid. Ash content was determined by placing porcelain dishes with dry samples in a furnace at 550°C for 5 hours and cooled to room temperature, each dish with ash was weighed and the content was estimated. The ether extract was determined using the Soxhlet method, fat was extracted into a Soxhlet extractor for 6 hours by heating solvent in the boiling flask. The flask with extracted fat was then dried in an oven and then cooled in a desiccator and weighed. The crude fibre was determined by alkaline/acid digestion and nitrogen-free extracts were obtained by the difference method (NFE= (DM-CP-EE-CF-Ash)).

Results

Water Quality

The mean water temperature in the earthen pond was higher (28.4±0.40) than the fibre tank (26.22±0.32) but was not significantly different (P>0.05) from each other). The water in both the culture system was slightly acidic and was significantly different (P<0.05).

Proximate Composition

The proximate analysis of *O. niloticus* cultured in fibre tank and the earthen pond is shown in table 2. The crude protein value recorded in the fish cultured in the tank was higher (32.01±0.11) than the value recorded in the fish cultured in the pond (28.87±0.41) and was therefore significantly different from each other (P>0.05). There were no significant variations (P<0.05) in the values recorded for crude fibre (CF) in the fish cultured in the tank and earthen pond.

Table 1: Mean ± SD Physiochemical Parameters of the Treated Water in Fibre Tank and Earthen Pond

Treatment	Temp. (°C)	pH	Dissolved oxygen (mg/L)	Nitrite (NO ₂) (mg/L)	Nitrate (mg/L)	Ammonia NH ₃ (mg/L)
Pond water	28.4 ^a ±0.40	5.86 ^a ±0.08	1.35 ^a ±0.04	8.08 ^a ±0.04	2.21 ^a ±0.04	23.5 ^a ±0.42
Tank water	26.22 ^a ±0.32	6.05 ^b ±0.04	1.45 ^a ±0.01	12.71 ^b ±0.02	2.67 ^a ±0.03	29.25 ^b ±0.21

Means along the same column with the same letter are not significantly different (p>0.05)

Table 2; Proximate Analysis of *O. niloticus* Cultured in Fibre Tank and Earthen Pond (Mean ±SD0

Samples	CP (%)	EE (%)	MOISTURE (%)	ASH (%)	CF (%)
Tank Fish	32.01 ^a ±0.11	17.59 ^a ±0.53	24.25 ^a ± 0.67	3.93 ^a ±0.15	4.31 ^a ±0.08
Pond Fish	28.87 ^b ±0.41	21.03 ^b ±0.25	26.94 ^b ± 0.25	2.97 ^b ±0.08	3.51 ^a ±0.13

Means along the same column with the same letter are not significantly different (p>0.05)

Discussion

Water Quality

The temperature of the aquatic environment has been reported to be important for ensuring the survival and normal metabolism of fish (Adewole and Olaleye, 2014). In both the culture systems, the water temperatures were within

the recommended range (25⁰C and 32⁰C for optimum growth (Adewole and Olaleye, 2014). The pH of the water in the pond was slightly acidic and this could be as a result of interaction between atmospheric air and water during the respiration process while the pH of the treated water in the fibre tank was within the acceptable range (6.0-8.0) for fresh water fishes (Olatunde, 2004). The low level of dissolved oxygen observed in this study could be attributed to the decomposition of uneaten feed and faecal matter because excess organic matter was reported to result in depletion of oxygen.

Proximate Composition

The protein content of both fish raised in the fibre tank and earthen pond was within the range reported by USDA (2010) for fish and fishery product but slightly higher than the findings of Dereseet *al.* (2019) and Fanuelet *al.* (2017) for *Oreochromisniloticus* from different lakes. This could be a result of the diet composition of the cultured fish. Lipid content has been reported to be used to classify fish. The ether extract in this study for both fish was higher than the report of Jimohet *al.* (2018) for *Oreochromisniloticus* fed different water melon seed meal inclusion diet and also higher than the report of Fanuelet *al.*(2017) for *O. niloticus* from different three ecosystems. The differences could be attributed to the availability of feed and feeding frequency, sex and size of the fish. The ash content in this study was slightly higher than the report of Olapadeet *al.* (2016) but was in accordance with the report of Geofferyet *al.* (2018) for cultured *clariasgariepinus* and also support the findings of Fanuelet *al.* (2017). The high level of ash (total minerals) observed in this study could be linked to the availability of these minerals in the water body and ability of the fish to absorb and assimilate them. The crude fibre content observed in this study was slightly lower than the values reported by Mary *et al.* (2014) for *O. niloticus* fed commercial and farm –made feed in earthen pond but was in agreement with the report of Jimohet *al.* (2018). The significant variations in chemical composition of fish could be interpreted by different possible factors Moisture content observed were lower than the values reported for cultured *oreochromisniloticus* and *clariasgariepinus* by Geofferyet *al.* (2018) and also lower than the moisture content reported for *oreochromisniloticus* by Olapadeet *al.* (2016).

Conclusion

The study concluded that *oreochromisniloticus* from both culture systems (earthen pond and fibretank) was an adequate dietary source of protein and other nutrients that are beneficial to humans, which are similar to otherfresh water fishes.

References

- Adewole, H. A. and Olaleye, V. F. (2014).Haematological Profiles of *Clariasgariepinus* Fingerlings Fed Graded Levels of Blood Meal-Bovine Rumen Digesta Blend Diets. *FUTA Journal of Researchn Sciences* (2): 236-245.
- Arannilewa, S.T., Salawu, A.O., Sorungbe, A.A. and Ola-Salawu, B.B. (2005).Effect of Frozen Period on the Chemical Microbiological and Sensory Quality of Frozen Tilapia Fish (*Sarotherodongalileaus*). *African Journal of Biotechnology* 4(8):852-855.
- Association of Official Analytical Chemist (2000). Official Methods of Analysis AOAC Washington DC, USA, 17th Edition.
- Deresa,T.D., Gordon, A.Z., Fikadu, R.A., Tafesse, K.E., Kyla, Z. and Murray, D. (2019). Proximate Analysis of Nile Tilapia (*Oreochromisniloticus*) Fish Fillet Harvested from Farmers Pond and Lake Hawassa, Southern Ethiopia. *International Journal for Research and Development in Technology* 11(1):2349-3585
- El-Zaeem, S.Y., Ahmed, M.M., Salama, M.S. and El-Kader, W.N. (2012). Flesh Quality Differentiation of Wild and Cultured Nile Tilapia (*Oreochromisniloticus*) Populations. *African Journal of Biotechnology* 11(17): 4085-4089
- Fanuel Jim, Penina G. and Colin Musara (2017). Comparative Analysis of Nutritional Value of *Oreochromisniloticus* (Linnaeus), Nile Tilapia, Meat from Three Different Ecosystems. *Journal of Food Quality*, Vol.10, 8pp
- Flos, R., Reig, L., Oca, J. and Ginovart, M. (2002). Influence of Marketing and Different Land-based Systems on Gilthead Seabream (*Sparusaurata*) Quality. *Aquaculture International* 10:189-206
- Foran, J.A., Good, D.H., Carpenter, D.O., Hamilton, M.C., Knult, B.A. and Schwager, S.J. (2005). Quantitative Analysis of the Benefits and Risks of Consuming Farmed and Wild Salmon. *Journal of Nutrition* 135(11):2639-2643.
- Geoffery, O.E, Elle M., Lambert, C.H., Yousseuf, A., Armand, B.G. and Phillippe, A. L. (2018). Proximate Composition of Cultured *Oreochromisniloticus* and *Clariasgariepinus* based on Commercial Feed in Benin. *International Journal of Agriculture, Environmental and BioResearch* Vol. 3 (5)

- Jimoh, W.A., Shittu, M.O., Abdulsalami, S.A., Okemakin, F.Y. and Ayeloja, A.A. (2018). Effect of Replacing Soybean Meal with Water Melon Seed Meal on the Growth, Feed Utilization and Body Composition of Nile Tilapia (*Oreochromis niloticus*). *Nigerian Journal of Animal Production* 45(2):59-66
- Mary, A.O., Cecilia, M.G., Jonathan, M.M. and Harrison, C. (2014). Growth Performance, Carcass Composition and Profitability of Nile Tilapia (*Oreochromis niloticus* L.) Fed Commercial and On-Farm Made Fish Feed in Earthen Ponds. *International Journal of Fisheries and Aquatic Studies* 1(5):12-17
- Olapade, O.A., Taiwo, I.O., Lamidi, A.A. and Awonaike, O.A. (2016). Proximate Composition of Nile Tilapia (*Oreochromis niloticus* L. 1758) and Tilapia Hybrid (Red Tilapia) from Oyan Lake, Nigeria. *Food Science and Technology* 73(1)
- United State Department of Agriculture (USDA) (2010). Agricultural Research Service, National Nutrition Data Base for Standard Reference Service. *Release*, 23 Nutrition Laboratories
- Zenebe, T., Ahlgren, G., Gustafsson, I.B and Boberg, M. (1998). Fatty acid and Lipid Content of *Oreochromis niloticus* L. in Ethiopian Lakes-Dietary Effect of Phytoplankton. *Ecology FreshwaterFish* 7(3):146-158.

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Microbiological Evaluation of Differently Processed Crabs

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Microbiological analysis of differently processed crabs (*Callinectesamnicola*) sourced from the Lagos Lagoon, Lagos State, Nigeria, was carried out using standard microbiological techniques. The Total Bacteria Count ranged from 3.48×10^5 CFU/g to 5.42×10^5 CFU/g for the fresh samples. The result showed that frozen drastically reduced the total bacteria load (6.6×10^3 - 18.04×10^3) on the crab samples than frying (1.14×10^4 - 3.8×10^4) and boiling (2.96×10^4 - 8.21×10^4). Frozen crab had the highest fungi count of 6.01×10^3 Cfu/g while fried crabs had the lowest count of 0.55×10^3 Cfu/g both in Day 3. There is no significant difference ($p > 0.05$) in the fungi count of the processed crabs in Day 1 and Day 2 of the experiment. However, significant variations ($p < 0.05$) existed among the differently processed crabs in Day 3. The identified isolates were *Bacillus* sp., *Coccobacillus* sp., *Enterobacter* sp., *Klebsiella* sp. and *Staphylococcus* sp. All the processed crab samples had *Bacillus* sp. and *Klebsiella* sp. in common while fried crab samples had the least identified bacteria. The detection of pathogenic bacteria in the differently processed crab samples implies that its consumption should be of public health importance.

Keywords: Crab, Boiling, Frozen, Frying, Lagos Lagoon, Pathogen

Introduction

Crabs are good source of animal protein, eaten either as snacks or as part of the main meal in Southern Nigeria (Moruf *et al.*, 2021). It requires careful handling because just like fish, crab spoils easily after capture due to the high tropical temperature, which accelerates the activities of bacteria, enzymes and chemical oxidation of the fat. Its preservation and processing slowdown or prevent enzymatic, bacterial, and chemical deterioration and maintain the muscle tissues in a condition as near as possible to that of fresh one (Bate and Bendall, 2010).

Crabs like fish products are available to customers in the tropics as fried, boiled or frozen. According to Oshamehinet *al.* (2013), prospective buyers with bare hands constantly touched most seafood in open markets, an unhygienic practice that could contribute significantly to increased microbial load. Being a benthic organism, crabs can accumulate human pathogenic bacteria, fungi and viruses when grown or sampled from sewage-contaminated waters. For instance, Uaboi-Egbenniet *al.* (2010), studied the significance of pathogenic bacteria in the gut of swimming crab, *Callinectes* sp. obtained from Lagos Lagoon while Oshamehinet *al.* (2013) studied the bacterial quality of dried crabs sold in various markets in Lokoja, Nigeria. However, the present research work is to evaluate microbiologically, fresh and the differently processed crab (*Callinectesamnicola*) obtained from Makoko Market Lagos, Nigeria.

Materials and Methods

The crab samples (*Callinectesamnicola*) used in this study were purchased for three months from Makoko seafood landing site, Lagos State, Nigeria. The crabs were deshelled and thoroughly washed. The samples were then separated into four parts, one part was analyzed raw; a second part was boiled in water, the third part was frozen while the last part was deep-fried with vegetable oil in a frying pan. Boiling was done in distilled water, kept boiling for about 20 minutes until the pieces were cooked and tender. Frying was achieved within 15 minutes and the temperature was about 240°C. All processing methods followed the usual procedures used to prepare shellfish for table consumption in Nigeria but without the addition of any ingredient. All samples were homogenized before analysis. Microbiological evaluation; total bacterial count and total fungal count and isolation of microorganisms from the stock were done as described by Krieg and Holt (1984). Data were analyzed using the descriptive statistic SPSS (version 20). Differences in mean of some analyzed data were considered significant at $P < 0.05$.

Results

The microbial load of bacteria isolated from differently processed crab samples is presented in Table 1. The Total Bacteria Count ranged from 3.48×10^5 CFU/g to 5.42×10^5 CFU/g for the fresh samples. The Total Bacteria Count

ranged from 3.48×10^5 CFU/g to 5.42×10^5 CFU/g for the fresh samples, 6.6×10^3 to 18.04×10^3 for frozen samples, 1.14×10^4 to 3.8×10^4 for fried samples and 2.96×10^4 to 8.21×10^4 for boiled samples.

Table 1: Total Bacteria Counts (Cfu/g) of differently processed crabs

Day	Fresh Crab	Fried Crab	Frozen Crab	Boiled Crab
1	3.48×10^5	2.28×10^4	6.6×10^3	2.96×10^4
2	5.02×10^5	3.8×10^4	14.37×10^3	5.27×10^4
3	5.42×10^5	1.14×10^4	18.04×10^3	8.21×10^4

Table 2 shows the fungi count of differently processed crab samples. Frozen crab had the highest fungi count of 6.01×10^3 Cfu/g while fried crabs had the lowest count of 0.55×10^3 Cfu/g both in the third day. There is no significant difference ($p > 0.05$) in the fungi count of the processed crabs in Day 1 and Day 2 of the experiment. However, significant variations ($p < 0.05$) existed among the differently processed crabs in third day.

Table 2: Total Fungi Counts ($\times 10^3$ Cfu/g) of differently processed crabs

Day	Fresh Crab	Fried Crab	Frozen Crab	Boiled Crab
1	1.30 ± 0.01^a	1.10 ± 0.01^a	2.20 ± 0.01^a	1.20 ± 0.01^a
2	1.87 ± 0.01^a	1.83 ± 0.01^a	4.79 ± 0.01^a	2.14 ± 0.01^a
3	2.03 ± 0.01^a	0.55 ± 0.01^b	6.01 ± 0.01^c	3.33 ± 0.01^a

Table 3 revealed the cultural, morphological and biochemical characteristics of bacterial isolates in the differently processed crab samples. The identified isolates were *Bacillus* sp., *Coccobacillus* sp., *Enterobacter* sp., *Klebsiella* sp. and *Staphylococcus* sp. All the processed crab samples had *Bacillus* sp. and *Klebsiella* sp. in common while fried crab samples had the least identified bacteria.

Table 5: Cellular morphology and biochemical characterization of bacteria isolated from differently processed crabs

	Gram reaction	Cell morph	Catalase	Oxidase	Indole	Mannitol	Citrate	Spor	Motility	Suspected Isolates
Fresh	+	Cocci	+	-	-	+	-	-	-	<i>Staphylococcus</i> sp.
	+	Rod	+	-	-	-	+	+	-	<i>Bacillus</i> sp.
	+	Cocci	+	-	-	-	-	-	-	<i>Coccobacillus</i> sp.
	-	Rod	+	-	-	-	+	-	-	<i>Klebsiella</i> sp.
Fried	+	Rod	+	-	-	-	+	+	-	<i>Bacillus</i> sp.
	-	Rod	+	-	-	-	+	-	-	<i>Klebsiella</i> sp.
	+	Cocci	+	-	-	-	-	-	-	<i>Coccobacillus</i>
Frozen	-	Rod	+	-	-	-	+	-	+	<i>Enterobacter</i> sp.
	+	Cocci	+	-	-	-	-	-	-	<i>S. aureus</i>
	+	Rod	+	-	-	-	+	+	-	<i>Bacillus</i> sp.
	-	Rod	+	-	-	-	+	-	-	<i>Klebsiella</i> sp.
	+	Rod	+	-	-	-	+	+	-	<i>B. megaterium</i>
Boiled	+	Rod	+	-	-	-	+	+	-	<i>Bacillus</i> sp.
	+	Cocci	+	-	-	-	-	-	-	<i>S. aureus</i>
	-	Rod	+	-	-	-	+	-	+	<i>Enterobacter</i> sp.
	-	Rod	+	-	-	-	+	-	-	<i>Klebsiella</i> sp.

Discussion

Bacteriological and mycological evaluations of fish and fish products are used by the industries and authorities for contractual and internal purposes and to check the microbiological status of the products (Jimoh et al., 2012). In this present study, the high load of microbiological contamination may be associated with the activities of humans and animals, which are the major sources of pollutants in the area of sampling collection. This finding agrees with the work of Sivasubramanian et al. (2017) that lagoons are constantly polluted with faecal matter from riverine dwellers.

All the processed crab samples had *Bacillus sp.* and *Klebsiella sp.* common while fried crab samples had the least identified bacteria. The bacteria isolated in this present study are similar to the microorganisms reported by Li *et al.* (2012) and Chen *et al.* (2015). The identification of *Staphylococcus sp.* counts in the fresh crab samples may be because crabs are usually selected out of heaps of stocks and they are constantly touched by both buyers and sellers, thus introducing and increasing the population of *S. aureus* (Orji *et al.*, 2016). Oshamehin *et al.* (2013) is of the view that staphylococcal counts exceeding 10^2 cells/g in seafood may be associated with gross mishandling and contamination.

In this study, we have identified *Enterobacter spp.* in the differently processed crab samples, which implies that its consumption should be of public health importance. The results were unable to determine if contamination occurred before the raw crabs were being processed. Another plausible explanation is that contamination occurred in the processing area, which is corroborated by previous investigations. According to Jimoh *et al.* (2012), contamination of fish particularly by pathogens may occur before harvest, during capture, processing, distribution and/or storage. Other studies dealing with different processing operations have similarly concluded that the plant and processing environment is the source of product contamination rather than the raw material. However, this does not exclude the possibility that the fresh crab or material is an important initial source for contaminating processing equipment and environment (Ferreira *et al.*, 2014).

Conclusion

The study showed that the differently processed crab samples harbour microorganisms including those that are pathogenic. The detection of *Enterobacter sp.* in the differently processed crab samples implies that its consumption should be of public health importance.

References

- Bate, E. C and Bendall, J. R. (2010). Changes in fish muscle after death. *British Medical Bulletin*, (12): 2305.
- Chen, X., Di, P., Wang, H., Li, B., Pan, Y., Yan, S. and Wang, Y. (2015). Bacterial community associated with the intestinal tract of Chinese mitten crab (*Eriocheirs sinensis*) farmed in Lake Tai, China. *PloS one*, 10(4): e0123990.
- Ferreira, V., Wiedmann, M., Teixeira, P. and Stasiewicz, M. J. (2014). *Listeria monocytogenes* persistence in food-associated environments: epidemiology, strain characteristics, and implications for public health. *Journal of food protection*, 77(1): 150-170.
- Jimoh, W. A., Iyanda, S. A., Adediji, F. A. and Ayelaja, A. A. (2012). Mycological evaluation of differently preserved tilapia fish in Abeokuta North Local Government, Nigeria. *Journal of Agricultural Science and Environment*, 12(2):36-44.
- Krieg, N. R. and Holt, J. G. (1984). *Bergey's Manual of Systematic Bacteriology*. Williams and Wikins, Baltimore, London.
- Li, S., Sun, L., Wu, H., Hu, Z., Liu, W., Li, Y. and Wen, X. (2012). The intestinal microbial diversity in mud crab (*Scylla paramamosain*) as determined by PCR-DGGE and clone library analysis. *Journal of applied microbiology*, 113(6): 1341-1351.
- Moruf, R. O., Taiwo, M. A. and Adebayo, Q. (2021). Nutritional and functional attributes of raw and grilled crabmeat. *Agricultural Science and Technology*, 13 (1): 83-90.
- Orji, J. O., Nnachi, A. U., Ekwuatu, C. C., Akujobi, C. N., Iwuafor, A. A., Efunshile, A. M. and Aghanya, I. N. (2016). Bacteriological quality of vended fresh shrimps harvested from Ndibe Beach, Afikpo North Local Government Area, Ebonyi State, Nigeria. *Sch. J. App. Med. Sci*, 4: 4058-4063.
- Oshamehin, G. O., Stephen, E. and Obi, S. K. C. (2019). Bacterial quality of dried crabs sold in various markets in Lokoja, Nigeria. *American Journal of Research Communication*, 1(7): 261-270.
- Sivasubramanian, K., Ravichandran, S. and Rajan, D. K. (2017). Isolation of gut associated bacteria from mangrove crabs collected from different mangrove regions of Tamil Nadu, South east coast of India. *African Journal of Microbiology Research*, 11(14): 586-595.
- Uaboi-Egbenni, P. O., Okolie, P. N., Famuyiwa, O. and Teniola, O. (2010). The significance of pathogenic bacteria in the gut of swimming crab, *Callinectes sp.* obtained from Lagos lagoon and market samples stored at freezer temperature (0°C). *Pakistan Journal of Nutrition*, 9(4): 398-403.

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Proximate Composition of Wild Biscuit (*Dictarium microcarpum*) Leaf and Seed Meals as Potential Ingredients for Fish Production

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Abstract

In order to enhance aquaculture production, improve food security, and reduce the level of poverty in developing countries, such as Nigeria, a search for inexpensive and locally available feedstuffs is required. The present study was designed to determine the proximate composition of wild biscuit (*Dictarium microcarpum*) leaf and seed meals as potential feedstuffs with a specific focus on underutilized plant carbohydrate sources by-products for fish production. Selection of the feedstuffs was based on availability, cost and the avoidance of conflicts with human consumption. Proximate analysis was conducted for wild biscuit leaf and seed meals to estimate their potential nutritive value for utilization as feedstuff for small-scale aquaculture. Based on their proximate composition, the results of the wild biscuit analysis shows that percentage moisture ranged from 6.20 to 6.21% (leaf meal) and 7.77 to 7.80% (seed meal). The concentration of protein ranges from 13.05 to 13.06% (leaf meal) and 14.48 to 14.50% (seed meal). The range for concentration of NFE was 45.67 to 45.70% (leaf meal) and 60.27 to 60.35% seed meal). Percentage fat ranged from 24.02 to 24.68% (leaf meal) and 60.27 to 60.35% (seed meal). While, the ash content ranged from 5.84 to 5.85% (leaf meal) and 2.61 to 2.62% (leaf seed meal). The values for the proximate indices of the leaf and seed meals were comparable to values reported for other non-convectional feedstuffs. The seeds of wild biscuit had higher values of crude protein, crude fat and NFE than leaf meal. Similarly, gross energy and metabolizable energy of the seeds of wild biscuit had higher values than the leaf meals. The wild biscuit leaf and seed meals were found to be good dietary energy sources of nutrient.

Key words: Wild biscuit by-products, energy sources, feed, nutrients, proximate analysis

Introduction

Nutrition plays a critical role in intensive aquaculture and influences not only the production cost but also fish growth, health and waste production (Gatlin III, 2002). Cost effective diets are essential for successful fish farming. The profitability and success of compounded feed production depend on cost, availability and digestibility of the feed used. Numerous unconventional feed ingredients for fish are mainly from plants and animal products especially by-products of processing plants but their usage is sometimes limited due to poor understanding of their nutritional and economic value as well as their utilization in fish feed. Therefore, there is need to search for less known materials suitable for fish feed such as wild biscuit (*D. microcarpum*) seed and leaf. This research work is important as it will contribute to the available information on the proximate composition of non-conventional feed resources (NCFR) in fish feed industry. This also contributes to increase in fish production as a result of mass production and generate employment especially in the rural areas as an asset to poverty alleviation scheme.

The high cost of fish feed inputs is a major problem to of aquaculture industry in Nigeria today (Madu *et al.*, 2003) and feed is an integral part and the most important cost item for intensive aquaculture. A major drawback with plant proteins is that the levels of the indispensable amino acids are not as high as those from animal proteins. Also, the presence of anti-nutritional factors presents a debilitating problem to their usage in the raw form. Shang (1981), Jauncey and Ross (1982), Hardy (1989), Lovell (1989) and Eyo (2003) all stated that nutrition in aquaculture accounts for 40 – 65% of the total operating costs, depending on the level of aquaculture intensification. Research on a suitable low-cost feed is therefore a high priority.

Wild biscuit (*Dictarium microcarpum*) is commonly known as sweet detar, sweet dattock or tallow tree. It is an underutilized species of tree legume that grows naturally in the drier regions of West and Central Africa. It has wide range of uses due to its medicinal properties, edible fruit (eaten raw, cooked, or made into flour with many uses of

its own) and hardwood which is used as fuel. The makes it valuable and appreciated by local communities, but further research and effort are needed for its domestication.

Wild biscuit (*D. microcarpum*) is an Africa tree belonging to the family Fabaceae (Legume family) (Abdulbasit *et al.*, 2009). It is a small tree or shrub growing up to 15 m tall but reaches in 25 m in moist areas (FAO, 1995). In terms of growth rate, the shoots of the trunk can reach a height of 1.5 m to 2 m in 1 to 2 years and are more vigorous than seedlings which on average grow to 0.6 m after 3 years and may reach 1.5 m 4 years. It flowers during the rainy season (July to September/November), but the main flowering period only lasts up to 8 days. It bears fruit from September – January/May and in November; the tree sheds its leaves and produces new leaves in March (Abdulbasit *et al.*, 2009).

Benefits of wild biscuit fruit tree: When ripe both the shell and the seed of the fruit are eaten, it has natural sugar content. The bark of the fruit tree can be mixed with water and thereafter the infiltrated water be taken in small cup as a cure to stomach ache (Kouyaté and van Damme, 2006). They serve as a source of food to other animals in the in their natural habitat. Large and matured of this fruit tree provides shade for healthy breeze and relaxation especially during the hot periods. They do not have a very long life span so naturally dead and died off ones can be used for firewood, etc. The objective of this study is to determine the proximate composition of wild biscuit (*D. microcarpum*) seed and leaf meals as potential ingredients for fish production.

Materials and methods

Collection and processing of wild biscuit (*Dictarium micrcarpum*) leaf and seed meals

D. microcarpum samples were obtained from the premix of Federal College of Freshwater Fisheries Technology, New Bussa. The collected samples were sundried and ground into fine powder using domestic grinding machine and analysed for proximate composition according to standard method of AOAC (2006).



Plate 1: Wild biscuit (*Dictarium micrcarpum*) leaves



Plate II: Wild biscuit (*Dictarium micrcarpum*) seeds

Moisture content

Moisture content of *Dictarium microcarpum* were determined by drying the leaves and seeds (in triplicate) in a Gallenkamp oven at 105°C until constant weight was attended (AOAC, 2006).

Ash content

Ash content was determined by dry ashing in Lenton muffle furnace at 525°C for 24hours.

Crude protein content

Crude protein content was calculated by multiplying the values obtained from Kjeldahl's nitrogen by a protein factor 5.3, a factor recommended for vegetable analysis (Bernice and Merrill, 1975).

Crude lipid

Crude lipid was quantified by the method described by (AOAC, 2006) using the solvent apparatus and n-hexane as a solvent.

Crude fibre Crude fibre was estimated by acid-based digestion with 1.25% H₂SO₄ (w/v) and 1.25% NaOH (w/v) solutions (AOAC, 2006).

Carbohydrates

Available carbohydrates were calculated by difference (i.e., total sum of crude protein, crude, fibre, crude, ash, and crude lipid deducted from 100% DM (AOAC, 2006). The sample calorific value was estimated (in kcal) according to the formula:

Energy = (g protein x 2.44) + (g lipid x 8.37) + (g available carbohydrate x 3.57) (Asibey-Berko and Taye, 1999).

Statistical Analysis

The results are presented as the mean±SD (standard deviation). All data were analyzed by one-way analysis of variance (ANOVA) using the software of the SPSS 17.0 for Windows. Student's t-test was performed to separate differences among means. The differences are considered significant at P≤0.05.

Results**Proximate Composition of Wild Biscuit Leaf Meal**

The proximate composition of wild biscuit (*Dictarium microcarpum*) leaf meal is presented in Table 1. Results of the proximate contents of the leaf meal showed that *D. microcarpum* leaf contains 93.80% dry mater, 13.06% crude protein, 5.85% ash, 7.02% crude fat, 22.19% crude fibre and 45.68% nitrogen free extract.

Table 1: Proximate composition of wild biscuit (*Dictarium microcarpum*) leaf meal

Parameters	Sample 1	Sample 2	Sample 3	Mean
Moisture content (%)	6.20	6.20	6.21	6.20±0.01
Crude protein (%)	13.06	13.05	13.06	13.06±0.01
Ash (%)	5.84	5.85	5.85	5.85±0.01
Crude fat (%)	7.02	7.03	7.02	7.02±0.01
Crude fibre (%)	22.18	22.20	22.18	22.19±0.01
NFE (%)	45.70	45.67	45.68	45.68±0.02

Nitrogen free extract (Calculated by difference) = 100 – (moisture + protein + ash + fat + fibre)

Proximate Composition of Wild Biscuit Seed Meal

The proximate composition of wild biscuit (*Dictarium microcarpum*) seed meal is presented in Table 2. Results of the proximate contents of the seed meal showed that *D. microcarpum* seed contains 92.22% dry mater, 14.49% crude protein, 2.62% ash, 8.46% crude fat, 3.35% crude fibre and 60.30% nitrogen free extract.

Table 2: Proximate composition of wild biscuit (*Dictarium microcarpum*) seed meal

Parameters	Sample 1	Sample 2	Sample 3	Mean
Moisture content (%)	7.77	7.78	7.80	7.78±0.02
Crude protein (%)	14.48	14.50	14.48	14.49±0.01
Ash (%)	2.61	2.62	2.62	2.62±0.01
Crude fat (%)	8.45	8.46	8.47	8.46±0.01
Crude fibre (%)	6.34	6.35	6.36	3.35±0.01
NFE (%)	60.35	60.29	60.27	60.30±0.04

Nitrogen free extract (Calculated by difference) = 100 – (moisture + protein + ash + fat + fibre)

Proximate Composition of Wild Biscuit Leaf and Seed Meals

The proximate composition of wild biscuit (*Dictarium microcarpum*) leaf and seed meals are presented in Table 3. The results showed that the seeds are rich in essential nutrients. The crude protein content of the seed meal (14.49%) was higher than that of the leaf meal (13.06%). There was, however, significant difference in the values of the crude fibre, ash content and nitrogen free extract content.

Table 3: Proximate composition leaf and seed meals of wild biscuit (*Dictarium microcarpum*) (% dry weight)

Parameters	Wild biscuit leaf meal	Wild biscuit seed meal
Moisture content (%)	6.20±0.01	7.78±0.02
Crude protein (%)	13.06±0.01	14.49±0.01
Ash (%)	5.85±0.01	2.62±0.01
Crude fat (%)	7.02±0.01	8.46±0.01
Crude fibre (%)	22.19±0.01	3.35±0.01
Nitrogen free extract, NFE (%)	45.68±0.02	60.30±0.04
Gross energy (kcal/100g)	327.12	409.05
Metabolizable energy(kcal/100g)	298.14	375.30

Mean values±SD in the same row with different superscripts are significantly different ($p < 0.05$)

*Nitrogen Free Extract (NFE) is calculated by difference = 100 – (protein + fat + fibre + ash)

*Gross energy = Caloric value of protein 5.65, NFE 4.1 and lipid 9.45kcal/g (NRC, 1993)

*Metabolizable energy = Caloric value of protein 4.0, NFE 4.00 and lipid 9.0 kcal/g (Magdi, 2004). *SD = Standard deviation

Discussion

The leaf and seed meals of wild biscuit, *Detarium microcarpum* were found to contain sufficient amounts of the essential nutrients required by fish such as protein, carbohydrate and fat. These nutrients could supplement other dietary sources if the leaf and seed meals are served in adequate amount in diet (Christian, 2007).

The crude protein content (28.09 %) of the leaf meal seeds obtained in this study is comparable to the 24.40% value reported by Akwaowo *et al.* (2000). Christian, 2007 had also reported that *T. Occidentalis* seeds have 31.38% crude fat, 2.02% ash, 50.08% carbohydrate and fibre content of 2.12% while Akwaowo *et al.* (2000) reported 56.24% crude fat, 1.80% crude fibre, 1.60% ash and 16.10% carbohydrate. The fat (18.4 %), carbohydrate (2.41%), ash (1.53%) and crude fibre (0.88%) contents of the seeds as determined in the present study are lower than the values reported by these earlier workers. These differences may be attributed to genetic variations, as well as climate, environmental and geographical factors.

Conclusion

This study was conducted to assess the nutritive value of wild biscuit, *Detarium microcarpum* leaf and seed meals based on their proximate composition. The percentage concentration of moisture, ash, fat, protein crude fibre and carbohydrate were higher in the leaf meal than the seed meal. Comparison of the observed proximate parameter of the analysed wild biscuit leaf and seed meals with that of other non conventional feedstuffs and the nutrient requirement of the feedstuffs showed that they are good protein sources of nutrient supplement. Therefore, the potential of the wild biscuit leaf and seed meals as non conventional feed resources as the viable and economic sources feed ingredients for fish feed manufacturer cannot be overemphasised. They are readily available, cheap and do not compete with human consumption. Fish farmers and fish feed millers should look outwards to explore and utilize these non conventional feed resources maximally so as to make fish farming more economically viable, attractive and sustainable. This will be a major way forward in commercial fish farming.

Recommendation

It is obvious from this study that leaf and seed meals of wild biscuit would meet the carbohydrate needs of fish. It is recommended that both of the samples should be used as carbohydrate supplements in fish feed production.

References

- Abdalbasit, A. M., Mohamed, E., S. Mirghani, Ahmad, B. A. and S. I. Abdelwahab (2009). "DetariummicrocarpumGuill and Perr fruit proximate chemical analysis and sensory characteristics of concentrated juice and jam," *African Journal of Biotechnology* 8 no.17 (2009): 4217-4221<http://www.ajol.info/index.php/ajb/article/viewFile/62360/50337>. Accessed November 25, 2012.
- Adjahossou, S. G. C., Gouwakinnou, G. N., Houéhanou, D. T., Sode, A. I., Yaoitcha, A. S., Houinato, M. R. B (2016). Efficacité des aires protégées dans la conservation d'habitatsfavorablesprioritaires de ligneux de valeur au Bénin. *Bois etforêts des tropiques*, 328(2), 67–76.
- Akwaowo, E. U., B. A. Ndou and E. U. Efuk, (2000). Minerals and antinutrients in flute pumpkin (*T. occidentalis*Hook F.). *Food Chem.*, 70: 235-240.
- AOAC (2006). Official Methods of Analysis. Association of Official Analytical Chemists. 17th edition (K. Helrick Editor) Arlington pp 1230.
- Asibey-Berko, E. and F. A. K. Tayie, (1999). Proximate analysis of some under listed Ghanaian Vegetables. *Ghana J. Sci.*, 39: 91-92.
- Bernice, K. W. and A. L. Merrill, (1975). Handbook of the Nutritional Contents of Foods. US Department of Agriculture, New York. Dover Publishers Inc.
- Christian, A. (2007). Fluted pumpkin (*Telfairia occidentalis* Hook F.) Seed: a nutritional assessment. *Electronic Journal of Environmental, Agricultural and Food Chem.*2007; 6(2): 1787-1793.
- Eyo, A. A. (2003). Fundamentals of fish Nutrition and diet development: An Overview. In: Eyo, A.A (Ed). Proceedings of the National Workshop on fish feed development and feeding practices in Aquaculture. FISON/NIFFR/FAO-NSPFS. pp: 1-33.
- Gatlin III, D.M. (2002) Nutrition and Fish Health. In: Halver, J.E. and Hardy, R.W., Eds., *Fish Nutrition*, 3rd Edition, Academic Press, London, 671-702.
- Hardy, R. W. (1989). Diet preparation. In: Halver, J.E. (Ed.), *Fish nutrition*. Academic Press Inc. California, pp. 475-548.
- Jauncey, K. and Ross, B. (1982). A guide to tilapia feed and feeding. University of Stirling, Scotland, UK.
- Kouyaté, A. M., and van Damme, P. (2006). *Detarium microcarpum* Guill. and Perr. In G. H. Schmelzer and A. Gurib-Fakim (Eds.), *Prota 11(1): Medicinal plants/Plantes médicinales 1. [CD-Rom]*. Wageningen: PROTA.
- Lovell, R. T. (1989). Nutrition and Feeding of Fish Van MostrandReinhold, New York, 260.
- Madu, C. T., Okwuego, C. C. and Madu, I. D. (2003). Optimum dietary protein level for growth and gonadal maturation of female *Heterobranchus longifilis* (Valenciennes 1840) Broodstock. *Journal of Aquatic Science*. 18 (18):29-34.
- Magdi, A. O., (2004). Chemical and nutrient analysis of Baobab (*Adansonia digitata*) Fruit and Seed protein solubility. *Plant. Food. Hum. Nutr.*, 59: 29-33.
- NRC (National Research Council), (1993). Nutrient requirements of fish. Washington, DC, USA, National Academy Press, 114p.
- Shang, Y. C. (1981). Aquaculture Economics Basic Concepts and Methods of Analysis. Westview Press, Boulder, CO, and Croom Helm, London. 124pp.

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Proximate and Mineral Compositions of Cuttlefish, *Sepia officinalis* (Linnaeus, 1758), Off Lagos Coast, Nigeria

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Abstract

Cuttlefish (*Sepia officinalis*) belonging to the class cephalopod are considered to have some essential nutrients such as protein, carbohydrate, lipids and minerals for the growth and healthy living of human being. There are approximately 100 cuttlefish species globally. The proximate and mineral analyses were conducted on the head and mantle of cuttlefish (*Sepia officinalis*) from Lagos coast. Proximate analysis result showed that head/mantle of *Sepia officinalis* contained 19.19±0.12 - 20.82±0.23% protein, 4.23±0.07% - 6.86±0.12 % ash, 2.57±0.02% - 3.76±0.05% fat, 69.99±0.28% - 72.24±0.32% moisture and 0.14±0.00% - 0.16±0.03% nitrogen free extract. There were no significant differences ($P>0.05$) across the seasons. Mineral analysis showed high contents of phosphorus, sodium and potassium with phosphorus content being the highest (943.88-2235.00 mg/kg). There were significant differences ($P>0.05$) across the season within the minerals. All the aforementioned nutritional components have been calculated on wet weight basis. Thus, the present study showed that cuttlefish contain essential nutrients for human good health with high protein and mineral content and is therefore an alternative candidate to overexploited fin fishes.

Key words: Cuttlefish, proximate composition, mineral, Off Lagos Coast.

Introduction

The fisheries landing and consumption of cephalopods have been increasing worldwide during the past decades. This tremendous increasing demand of cephalopods was due to its good quality protein and lipid source (Zlatanov *et al.*, 2006); hence, a highly nutritious food that serve as an alternative to over exploited fish resources. The world cephalopod catch increased from 0.58 million tons in 1950 to 3.51 million tons in 2003 while the all India cephalopod catch increased from 400 tons in 1957 to 89,353 tons in 2003 (Fishstat, 2004). The class Cephalopods including cuttlefish, squid and octopus are among an important marine resource because of their excellence taste with few inedible parts. Ozyurt *et al.*, (2006) and Thanonkaew *et al.*, (2006), reported that cuttlefish contained low level of lipid, in which omega-3 polyunsaturated fatty acid represented the major total lipid. Some scientists have worked on the nutritional composition of cuttlefish (Thanonkaew *et al.*, 2006; Villanueva *et al.*, 2004; Ozyurt *et al.*, 2006; Phillips *et al.*, 2002). However, this composition can vary with body part or organ; furthermore, this composition could also vary among species due to geographical differences of fishing grounds. Therefore, this study was conducted to determine nutritional composition of the cuttlefish head and mantle.

Materials and Methods

Sample collection

A total of 25 Samples of cuttlefish (Plate 1) used for the study were obtained off Lagos Coast between longitudes 2° 45' and 3° 60' and latitude 6° 20' and 6° 34'. These samples were washed with distilled de-ionised water to remove any adhering contamination, drained and identified according to FAO identification guide (Adebiyi, 2013). The specimen were kept in crushed ice in insulated containers and brought to the laboratory for refrigeration (- 20° C) prior to analysis.



Plate 1: Dorsal view of Cuttlefish (*Sepia officinalis*).
Source: Field work (2020).

Sample Analysis

Proximate Analysis

The proximate composition was determined according to AOAC (2005) methods. Crude protein content was analyzed using the Kjeldahl method; crude lipid content referred to the Soxhlet method; while ash content was dried over-night at 550°C. Moisture content was by drying samples overnight at 105°C until constant weight was achieved, as well as carbohydrate content was calculated by differences.

Mineral Analysis

Minerals component were evaluated from solution obtained by first wet-ashing the samples and dissolving the ash with de-ionized water and concentrated hydrochloride acid in standard flask. The solution was analysed for minerals content using Atomic Absorption Spectrophotometer (Buck Scientific 210 GVP model following the procedure of (Morufet *al.*, 2021). Phosphorus was determined colorimetrically using spectrophotometer as described by Santiet *al.*, (2019)

Data Analysis

Mean and standard Error were derived from data obtained and subjected to analysis of variance (ANOVA), Pearson Correlation Coefficient at significant difference of $P \leq 0.05$

Results

The results of proximate composition within the organs (mantle and head) of *Sepia officinalis* obtained off Lagos coast showed that mantle had higher crude proteins ($20.82 \pm 0.23\%$) than head ($19.19 \pm 0.12\%$). Although, higher crude fat was recorded in the head ($3.76 \pm 0.05\%$) than in the mantle ($2.57 \pm 0.02\%$) of *S. officinalis*. Crude fibres were not detected within the organs of *S. officinalis* obtained from Lagos coast, Nigeria. There were significant differences ($P < 0.05$) within the organs (mantle and head) of *S. officinalis* as shown in (Table 1). Seasonally, there were no significant differences observed in both seasons ($P < 0.05$) (Table 2)

Table 1: Proximate composition in mantle and head of *S. officinalis* obtained off Lagos coast.

Composition (%)	Mantle	Head
Moisture	72.24 ± 0.32^a	69.99 ± 0.28^b
Crude Protein	20.82 ± 0.23^b	19.19 ± 0.12^c
Crude Fat	2.57 ± 0.02^a	3.76 ± 0.05^b
Crude Fibre	ND	ND
Total Ash	4.23 ± 0.07^a	6.86 ± 0.12^b
NFE	0.14 ± 0.02^b	0.16 ± 0.03^c

Keys: ND: Not detected; NFE: Nitrogen Free Extract; Mean $\pm$ Standard deviation of mean; Mean values with the same superscript letters along the row were not significantly different at ($P > 0.05$)

Table 2: Proximate composition of cuttlefish, *Sepia officinalis* off Lagos coast across seasons

Wet (%)			Dry (%)		
Parameters	Head	Mantle	Parameters	Head	Mantle
Moisture	70.44±0.21 ^a	73.55±0.13 ^a	Moisture	69.10±0.28 ^a	71.79±0.43 ^a
Crude protein	18.71±0.17 ^a	20.33±0.08 ^a	Crude protein	19.29±0.15 ^a	21.47±0.33 ^a
Crude fat	4.15±0.08 ^a	3.67±0.00 ^a	Crude fat	3.95±0.03 ^a	2.71±0.02 ^a
Ash	6.55±0.07 ^a	3.35±0.05 ^b	Ash	7.48±0.1 ^a	3.90±0.11 ^b
NFA	0.14±0.00 ^a	0.12±0.00 ^a	NFA	0.18±0.01 ^a	0.14±0.01 ^a

Keys: Mean±Standard Error; values with different superscripts across row are significantly different at (P < 0.05)

The result of mineral composition within organs (mantle and head) of *Sepia officinalis* collected off Lagos coast as shown in (Table3) revealed that higher Sodium (Na) and Phosphorus contents were found in the head with mean value of (1.24±0.06mg/100g) and (2235.00±104.93mg/100g) than in the mantle (0.46±0.47mg/100g) and (943.88±27.21mg/100g) of *S. officinalis*, while, the mantle had higher potassium with mean value (0.43±0.44mg/100g) than in the head (0.29±0.22mg/100g) respectively. However, phosphorus was predominant within the organs. There were significant differences (P < 0.05) in the mineral compositions within the organs (mantle and head) of *S. officinalis* from Lagos coast. The mineral contents was arranged in descending order; Mantle; P>Na>K>Mg>Ca and Head; P>Na>K>Ca>Mg respectively.

Table 3: Mineral concentrations in mantle and head of *S. officinalis* off Lagos coast

Mineral (Mg/100g)	Mantle	Head
Sodium (Na)	0.46±0.47 ^a	1.24±0.06 ^b
Calcium (Ca)	0.0011±0.81 ^a	0.0302±0.003 ^a
Potassium (K)	0.43±0.44 ^a	0.29±0.22 ^a
Magnesium (Mg)	0.005±0.00 ^a	0.0082±0.00 ^a
Phosphorus (P)	943.88±27.21 ^a	2235.00±104.93 ^b

Mean values with the same superscript letters along the row were not significantly different at (P < 0.05)

The seasonal variation of the mineral composition of organs (mantle and head) of *Sepia officinalis* obtained off Lagos coast are shown in (Table4). The result showed that head had higher Na (0.61±0.00mg/100g) and P (2203.36±0.00mg/100g) contents than the mantle (0.45±0.00mg/100g) and (925.57±0.00mg/100g) of *S. officinalis*. However, higher K (0.42±0.00mg/100g) and Mg (0.21±0.00mg/100g) were recorded in the mantle compared with the head K (0.14±0.00mg/100g) and Mg (0.10±0.00mg/100g) respectively during the wet season. While, in the dry season higher concentration of Na (0.64±0.00mg/100g) and Mg (0.29±0.00mg/100g) were found in the head than in the mantle (0.47±0.00mg/100g) and (0.22±0.00mg/100g) of *S. officinalis* obtained from Lagos coast, Nigeria. The result also showed that mineral compositions were significantly higher (P < 0.05) within the organs during the dry season than wet seasons.

Table 4: Mineral composition of cuttlefish, *Sepia officinalis* off Lagos Coast across seasons

Wet (%)			Dry (%)		
Mineral	Head	Mantle	Mineral	Head	Mantle
Na	0.61±0.00 ^a	0.45±0.00 ^a	Na	0.64±0.00 ^a	0.47±0.00 ^a
Ca	0.03±0.00 ^a	0±0.00 ^a	Ca	0.03±0.00 ^a	0±0.00 ^a
K	0.14±0.00 ^a	0.42±0.00 ^a	K	0.15±0.00 ^a	0.44±0.00 ^a
Mg	0.10±0.00 ^a	0.21±0.00 ^a	Mg	0.29±0.00 ^a	0.22±0.00 ^a
P	2203.36±0.00 ^a	925.57±0.00 ^b	P	2318.33±0.00 ^a	962.19±0.00 ^b

Keys: Mean±Standard Error; values with different superscripts across row are significantly different at (P < 0.05)

Correlation Coefficient of Proximate and Mineral Compositions of *Sepia Officinalis* organs (Mantle and Head) collected off Lagos coast.

Details of the correlation analyses between proximate and mineral compositions in the organs (head and mantle) of *S. officinalis* collected from Lagos coast are shown in (Tables 5 and 6). Crude protein showed negative correlation with all the minerals in *S. officinalis* (head) from Lagos coast except with Na (0.69) and K (0.69) that was positively correlated. Crude fat positively correlated with all the minerals but strongly correlated with Mg (0.98) and P (1). Negative correlation was also observed between ash and all the minerals with an exception in Na (0.62) and K (0.63) and nitrogen free extract (NFE) positively correlated with all the minerals except in Na (-0.53) and K (-0.55). The correlation analysis between proximate and mineral content of mantle showed that crude protein correlated

positively with all minerals except with P (-0.33), however, no correlated was observed with Ca(0.00). Crude fat negatively correlated with all the minerals except with Ca(0.01) and P(0.32). Positive correlation was observed between ash and all minerals with an exception of Ca (-0.01) and (-0.32) and NFE positively correlated with all minerals except with Ca (-0.87).

Table 5: Correlation coefficient between proximate and mineral compositions in the head of *S. officinalis*

	Moisture	Crude Protein	Crude Fat	Ash	NFE	Na	Ca	K	Mg	P
Moisture	1									
Crude Protein	-0.96	1								
Crude Fat	0.06	-0.33	1							
Ash	-0.93	1	-0.42	1						
NFE	0.89	-0.98	0.51	-0.99	1					
Na	-0.86	0.69	0.46	0.62	-0.53	1				
Ca	0.69	-0.86	0.77	-0.90	0.94	-0.22	1			
K	-0.87	0.69	0.45	0.63	-0.55	1	-0.24	1		
Mg	-0.14	-0.13	0.98	-0.22	0.32	0.63	0.62	0.62	1	
P	-0.07	-0.21	1	-0.30	0.40	0.57	0.68	0.55	1	1

Table 6: Correlation coefficient between proximate and mineral compositions in the mantle of *S. officinalis*

	Moisture	Crude Protein	Crude Fat	Ash	NFE	Na	Ca	K	Mg	P
Moisture	1									
Crude Protein	-0.99	1								
Crude Fat	1	-0.99	1							
Ash	-0.99	1	-1	1						
NFE	0.46	-0.50	0.49	-0.49	1					
Na	-0.58	0.54	-0.54	0.54	0.46	1				
Ca	0.04	0.00	0.01	-0.01	-0.87	-0.84	1			
K	-0.56	0.52	-0.53	0.53	0.48	1	-0.86	1		
Mg	-0.54	0.50	-0.51	0.51	0.50	1	-0.87	1	1	
P	0.29	-0.33	0.32	-0.32	0.98	0.62	-0.94	0.64	0.65	1

Discussion

Finfish and shellfish form an essential component of the human diet due to its availability and affordability potential. Their contribution to the world food resources is usually estimate by the value of crude protein. Biochemical composition of organisms are known to vary with season, species, size of animal, stages of maturity and availability of food and temperature (Ramasamy, *et al.*, 2012). Cephalopods have being reported to have 20% more protein, 80% less ash, 50 to 100% less lipid and 50 to 100% less carbohydrate in comparison with fish. Ramasamy, *et al.*, (2012) also reported that mantle of cephalopods does not accumulate lipid below 1 g of its wet weight. The highest moisture content ($72.24 \pm 0.32\%$) obtained in the mantle of *S. officinalis* was lower than that reported by Ozogul *et al.*, (2008) on moisture content ($81.50 \pm 0.56\%$) mantle of *S. kubiensis* and Thanonkaewet *al.*, (2006) also reported higher water content on (*Sepia pharaonis*) with mean value of 84.42 ± 0.13 g / 100 g wet base. The variation in moisture content values could be as a result of species differences, habitat and age of organism. Protein being the second most abundant component found in *S. officinalis* after moisture. Vairamani (2010) reported higher protein content (36.36%) in the mantle of *Sepiellainermis* compared to the one reported in the present study on mantle of *S. officinalis* with crude protein content value of ($20.82 \pm 0.23\%$), however, the value of protein is higher than the one reported by Santiet *al.*, (2019) on mantle *Sepia sp* and Thanonkaewet *al.*, (2006) on *S. pharaonis*. Cuttlefish fat on the head (3.76 ± 0.05) produced in this study is greater than the fat produced on head (0.52%) of *S. pharaonis* by Thanonkaewet *al.*, (2006). The difference in fat levels produced in this study with other studies could be as a result of differences in eating habits, differences in digested food and availability of food in habitat. In the present study, the ash content on mantle and head of *S. officinalis* was estimated as 4.23 ± 0.07 (mantle) and 6.86 ± 0.12 (head) which is greater than the ash content of *Sepia officinalis* as $2.11 \pm 0.64\%$, *L. vulgaris* as $1.95 \pm 0.44\%$, *Eledonemos-chataas* $1.85 \pm 0.33\%$ and *Octopus vulgaris* as $2.06 \pm 0.11\%$ by Ozogulet *al.*, (2008). Lourenco *et al.* (2009) found that the main elements of common cephalopods were S, Cl, K, Na, P, Mg and Ca. In

the present study phosphorus was prominent than other element, this is different from the study of Santiet *al.*, (2019) who reported sodium to be prominent in *S. recurvirostra*. Cephalopods are known as carnivorous and active predators. As they have very high feeding rates, most part of the elements can be assumed to be incorporated by the diet. Minerals also absorbed by digestive gland as they swallow massive quantities of sea water during and after feeding (Wells and Wells, 1989). Minerals are required for the maintenance of normal metabolic and physiological functions of living organisms.

Conclusion

This study showed that cuttlefish *Sepia officinalis* are excellent in essential nutrients for human good health with high in protein and mineral content, but low in lipid content, it also established that nutrients composition in edible parts of cuttlefish didn't vary with season. Hence, it is therefore recommended as alternative to fin fish.

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References

- Adebisi, F. A. (2013). Growth pattern of the big eye grunt *Brachydeuterus auritus* (Valenciennes, 1832) off Lagos, Nigeria. *Indian J Fish*, 60, 9-12.
- Santi, A., Metasulach, G. D., and Mahendradatta, M. (2019). Proximate and mineral composition of cuttlefish (*Sepia* sp). *Int J Sci Res Sci Technol*, 6(4), 130-137.
- AOAC Association of Official Analytical Chemist (2005). Official Method of Analysis of the Association of Official Analytical of Chemist. Arlington (USA): The Association of Official Analytical Chemist, Inc.
- Fishstat (2004). FAO Fisheries Department, Fisheries information, Data and Statistics Unit. FISHSTATPlus: *Universal software for fisheries statistical time series*. Version 2.3, 2000.
- Lourenco, H.M., P. Anacleto, C. Afonso, V. Ferrara, M.F. Martins, M.L. Carvalho, A.R. Lino and M.L. Nunes, (2009). Elemental composition of cephalopods from Portuguese co.
- Moruf, R. O., Durojaiye, A. F., & Taiwo, M. A. (2021). Comparison between the proximate and mineral compositions of feral and cultured gecarcinid crab. In *46th Annual Conference, Nigerian Society for Animal Production*. Dutsin-Ma.
- Ozyurt, G., O. Duysak, E. Akama and C. Tureli, (2006). Seasonal change of fatty acids of 'pancreas'. *J. Exp. Biol.*, 145: 215-226.
- Ozogul, Y., Duysak, O., Ozogul, F., Özkütük, A. S., and Tureli, C. (2008). Seasonal effects in the nutritional quality of the body structural tissue of cephalopods. *Food Chemistry*, 108(3), 847-852.
- Phillips, K.L., P.D. Nichols and G.D. Jackson, (2002). Lipid and fatty acid composition of the mantle and digestive gland of four Southern Ocean squid species: Implications for food-web studies. *Antar. Sci.*, 14(3): 212-220.
- Ramasamy, P., Subhapradha, N., Sudharsan, S., Seedeve, P., Shanmugam, V., and Shanmugam, A. (2012). Nutritional evaluation of the different body parts of cuttlefish *Sepia kobeensis* Hoyle, 1885. *African journal of food science*, 6(22), 535-538.
- Thanonkaew A, Benjakul S, Visessanguan W (2006). Chemical composition and thermal property of cuttlefish (*Sepia pharaonis*) muscle. *J. Food Compos. Anal.* 19:127-133.
- Vairamani S (2010). Studied on biochemical composition, polysaccharides and collagen from *Sepiella inermis* Orbginy 1848. Ph.D Thesis, Khadhir Mohideen College, Tamil Nadu, India. p. 223.
- Villanueva, R., J. Riba, C.R. Capillas, A.V. Gonzalez and M. Baeta, (2004). Amino acid composition of early stages of cephalopods and effect of amino acid dietary treatments on *Octopus vulgaris* paralarvae. *Aquaculture*, 242(14): 455-478.
- Wells, M.J. and J. Wells. (1989). Water uptake in a cephalopod and the function of the so-called cuttlefish, *Sepia officinalis* L. (mollusca: cephalopoda) in the north eastern Mediterranean Sea. *Food Chem.*, 95(3): 382-385.
- Zlatanov S, Laskaridis K, Feist C, Sagredos A (2006). Proximate composition, fatty acid analysis and protein digestibility-corrected amino acid score of three Mediterranean cephalopods. *Mol. Nutr. Food Res.* 50:967-970.

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Artisanal Fish Smoking Activities In Yewa Lagoon, Ogun State, Nigeria**¹Oyetade O.P., ²Olaoye J. O., ¹Nwekoyo V.E., ¹Akinde, A. O., ³Ojebiyi W.G., And ⁴Abubakar, M.I**¹Department of Aquaculture and Fisheries Management, Federal University of Agriculture Abeokuta (FUNAAB), Ogun State, Nigeria. PMB 2240, Abeokuta, Nigeria²Agricultural Media Resources and Extension Centre (AMREC), Federal University of Agriculture Abeokuta (FUNAAB), Ogun State, Nigeria. PMB 2240, Abeokuta, Nigeria³Agricultural Extension and Rural Development, Federal University of Agriculture Abeokuta (FUNAAB), Ogun State, Nigeria, PMB 2240, Abeokuta, Nigeria⁴Department of Aquaculture and Fisheries, University of Ilorin, Ilorin, Kwara State

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Abstract

The research studied the artisanal fish smoking practices in Yewa lagoon, Ogun State, Nigeria between July and September, 2018. Data for this study were collected with the aid of interview guide from 120 fish processors from four purposively selected villages within the lagoon area based on high intensity of fishing and fish processing activities. Data collected were analysed using descriptive and inferential statistics. Results obtained from the study showed the highest age distribution of the respondents (47.5%) were 31-40 years, and were mostly married (75%), their primary occupation is fish smoking (100%), with almost all the processors (98.3%) using firewood. The mean values indicated that smoking drums (mean =2.98) were the most commonly used smoking equipment while altona (mean=0.04) were rarely used among the fish processors in the study area. The major reason for engaging in fish smoking among majority (98.3%) of the fish processors was to prevent fish spoilage. Excessive smoke resulted to reddening of the eye and burns injury, hence the most serious among all the constraints faced by the processors in the area. Hence, this study acknowledged the position of the fish smokers on the importance and need for fish smoking to prevent fish spoilage.

Keywords: Artisanal, Constraints, Equipment, Fish smoking, Yewa lagoon**Introduction**

The fishery sub-sector of agriculture consists of three broad units: artisanal or small scale fisheries; industrial (or large scale fisheries) and the aquaculture, wherein the first two units are capture fishery and the latter, culture fishery (Akinwumi *et al.*, 2011). Among these three units, the artisanal fishery contributes the most significant percentage in terms of number of the people engaged in its activities and contribution to total fish production in the country (Oladimeji *et al.*, 2013). According to Oladimeji *et al.* (2013) as cited by Bonjoru *et al.* (2019), artisanal unit covers the operations of small-scale canoes, fisheries operating in the coastal areas, creeks, lagoons, inshore water and the inland rivers. Bolarinwa (2014) and Akinwumi *et al.* (2011) characterized the fishery to be labour intensive and asserted that the fishery is marked by low capital outlay, operational costs and low technology application. According to Suleimon and Tosan (2012), fishing inputs commonly used include and not limited to canoe with or without outboard engine, paddles, hooks, gill nets, cast nets, beach seining and drift nets. Preservation of fishes is a very important part of ensuring food security in the fisheries sub-sector (Pandey and Shukla, 2005). Fish smoking in Nigeria is the most widely practiced method of fish preservation and processing among artisanal sector: practically all species of fish available in the country can be smoked, and it has been estimated that 70–80% of the domestic marine and freshwater catch is consumed in smoked form (Akinyemi *et al.*, 2011). Traditional fish smoking are the major type of smoking employed in fishing communities, the kilns and ovens are poorly constructed and lack mechanisms for the control of smoke and heat production, all of which affect the efficiency of smoking and the quality of the final products. Hence, this study looked into the socio-economics characteristics of the fish smokers in Yewa lagoon, they smoking practices and their challenges.

Materials and Methods

A two stage sampling procedure was adopted. The first stage involved the purposive sampling of four of the villages surrounding the lagoon based on intensity of fishing and fish processing activities. In the second stage, 30 fish processors were randomly selected from each of the four communities. Thus, a sum of 120 fish processors which served as the Sample size for the study. Participant observation was also used by the researcher to record

observations that were not captured within the interview guide. Data collected was through semi-structured interview guide with the help of enumerators and using descriptive and inferential statistics.

Results and Discussion

The socio-economic status of the respondents in the four settlements of Yewa lagoon is presented below (Table 1). The age distribution of the respondents shows that almost half of the respondents (47.5%) were in the age bracket of 31-40 years while 28.3% and 24.2% were in 20-30 and 41-50 years age brackets respectively. This implies that the dominating age bracket are youths which are in the active stage of their life and with corresponding strength for the chosen (fish smoking activities) occupation. According to the findings of Odulate *et al.* (2014) and Olaoye *et al.* (2012), age is an important factor in fisheries activities since experience and strength are always needed. Table 1 further gathered that 75.0% of the respondents were married, while 8.3% are single. Higher proportion (63.3%) of the respondent was into monogamous family while only 36.7% were practicing polygamy. The greater percentage of the fish smokers being married is an indication of the influence of the family unit on the marketing of the smoked fish. This is validated by the assessment of Abolagba and Chukwu (2008) who revealed that married couples in fish processing do better because they either bank on family responsibility or on the assistance of the husbands who maybe a fisherman and the need to assist the man. Furthermore, based on the number of persons in each household it was revealed that 47.5% of the respondents were from a family consisting of 12-20 members. Finally from Table 1, it can be seen that most of the respondents were Christians (51.7%), while 45.0 percent were Muslims. The educational status showed that more than half (53.3%) had primary school education with only few people attempting post primary and secondary levels (0.8%) education.

Family labour plays a key role in fish smoking enterprise, the result of this study has family as the highest form of labour contribution at 65.8% with the least from hired (1.7%). From the years of smoking experience, 22.5% have less than 10 years of smoking experience, 62.5% have smoking experience between 10-20 years. Furthermore, 14.2% and 0.8% of the population have between 21-30 years and more than 30 years of smoking experience respectively. On the mode of operation, 83.3% claimed to be involved in full time smoking while 16.7% claimed to do fish smoking as a part time job. As it has been observed fish processing is the primary occupation mostly for female, it therefore shows that they do it daily or most of the time. The greater percentage of the fish smokers being married is an indication of the influence of the family unit on the marketing of the smoked fish. This is validated by the assessment of Abolagba and Chukwu (2008) who revealed that married couples in fish processing do better because they either bank on family responsibility or on the assistance of the husbands who maybe a fisherman and the need to assist the man. This study discovered that the sampled fish processors were committed to fish smoking. This is in line with the assertion of Abolagba and Odiko (2005) who stated that majority of fish processors have little or no other job apart from fish smoking practice in his study area.

On fuel wood used for fish smoking, almost all (98.3%) of the respondents was using firewood as a source of heat for smoking the fish while only few people i.e. 1.7% used charcoal. This may be because of the availability or enough forest in the town. It may also be due to high cost of charcoal. The popular use of firewood as the energy source indicated its abundance in the study area which is in agreement with the works of Adeyeye *et al.* (2015) wherein majority of the fish processors in Lagos State (77.5%) prefers it to other sources of energy. Eighty-four percent of the respondents were fish processors and 15% of the respondents were traders according to Table 2 below.

On the type of equipment used for smoking in the lagoon area, Table (3) below indicates that smoking drums were the most commonly used representing 117 respondents. The popularity in the use of smoking drum over other equipment in the study area could be associated to the fact that smoking drum is less expensive and efficient for their use when compared to others. Adeyeye *et al.* (2015) in the survey of traditional fish smoking in Lagos Nigeria observed that the number of those using smoking drum is higher than other equipment thus validating this study. On the contrary, Adeokun *et al.* (2006) saw it as a characteristic feature of artisanal fishery which involves the application of low technology. Other equipment for smoking such as the use of mud (110), pit oven (104) pot oven (97) were rarely used for fish smoking in the area. However, modified Ivory Coast kiln, Altona kiln, Kaiji gas kiln, Chorkor smoking kiln, Altona oven, Ivory Coast oven and Adjetey oven were reported not available in the area for fish smoking. Hence, it can be deduced that only four smoking equipment were used in the area (smoking drum, smoking mud, pit oven and pot oven). (98.3%) smoked fish so as to prevent spoilage which according to the respondents on the long run creates economic and food security for them. Hence, Fregene and Bolorunduro (2009) attest to the findings from this study that without fish smoking and other forms of preservation methods fish spoilage

and loss will be enormous in the region. Other major reasons include; improving the taste of the fish (72), value addition for increased profit (92) respondents. Furthermore, 93 of the respondents major reason was also to get employed, 61 choose to keep one self-busy as not a reason for involving in fish smoking practices while 101 respondents responded that to meet the need of the and lastly, for quick return 90 choose this as a major reason for fish smoking. Among the constraints faced by fish smokers in Yewa lagoon fishing community, Table 5 showed that losses incurred through fish spoilage, occupational hazards such as minor cut and scrapes during cutting of fish, fall injury, sting from fish spines during fish handling, whitlow, red eye and burn injuries and excess smoke during smoking were the major constraints faced by the fish smokers. Other constraints include; poor transportation, lack of financial support and unavailability of improved fish smoking equipment. The result showed that red eye and burn is the most serious among all the constraints faced by the processors in the area. These injuries are caused by excessive smoke during smoking. It is important to note that this result corroborated the finding of Olaoye *et al.* (2017) that chemical hazards such as smoke had the highest impact on the fish processors of Ogun waterside.

Conclusion and Recommendation

The socio-demographic characteristics of the respondents provide the information that age and family size plays major role in the success of fish processing enterprise. The level of commitment shown in the operation is indicated by the fact that they had no occupation but fish smoking, and as such they reason for practicing fish smoking addressed and assured food security (by reducing post-harvest losses), income generation, employment and livelihood support system in the study area. It is apparent to note that the use of primitive equipment exposed the fish smokers to different types of occupational hazards of which red eyes and burns had the must impact among them. This study thus recommends that there is need for financial support as well as sensitization programs on better, safer and efficient smoking equipment and methods obtainable in 21st century.

Table 1: Socio-demographic characteristics of the fish processors at Yewa lagoon

Table 1: Socio-demographic characteristics of the non-prosecutors at Fawa Region													
Variables	Age				Sex		Ethnicity		Marital status				
	< 30 years	31 – 40	– 41 – 50	–	Male	Female	Yoruba	Igbo	Single	Married	Divorced	Widowed	
Percentage observed	28.3	47.5	24.2		91.7	8.3	96.7	3.3	8.3	75	2.5	14.2	
Variables	House hold size				Religion			Education					
	1 – 5	06- Nov	Dec- 20	> 20	Christian	Islam	Tradition	No formal	Primary	Secondary	Tertiary		
Percentage observed	25.8	24.2	47.5	2.5	51.7	45	3.3	41.7	53.3	4.2	0.8		
Variables	Family type												
	Monogamy	Polygamy	Single										
Percentage observed	63.3	36.7	8.3										

Table 2: Fish smoking characteristics of the fish processors at Yewa lagoon

Table 2: Fish smoking characteristics of the fish processors at Fawa region													
Variables	Labour used			Experience							Smoking operation		
	Famil y	Labou r	Hir ed	Family labour	and	Tot al	<10yea rs	10- 20year s	21- 30	>30y ears	Tot al	Full time	Part time
Observed Percentage	65.8	8.3	1.7	24.2		100	22.5	62.5	14.2	0.8	100	83.3	16.7
Variables	Fuel wood			Secondary occupation									
	Charc oal	Firew ood	Tot al	None		Tra der	Lumbe ring	Total					
Observed Percentage	98.3	1.7	100	84.2		15	0.8	100					

Table 3: Smoking equipment used in Yewa lagoon for fish smoking

	Frequency of use					Mean $\pm$ s.d
	Most (3)	common	Common(2)	Rarely used(1)	Not available(0)	
Smoking drum	117		3	0.0	0.0	2.98 $\pm$ 0.157
Smoking mud	1		5	110	4	1.03 $\pm$ 0.316
Pit oven			7	104	9	0.98 $\pm$ 0.366
Pot oven	2		3	97	18	0.91 $\pm$ 0.483
Modified ivory coast	2		2	4	112	0.12 $\pm$ 0.488
Altona kiln	2		1	3	114	0.09 $\pm$ 0.449
Kaiji gas kiln			1	4	115	0.05 $\pm$ 0.254
Chorkor	1			4	115	0.06 $\pm$ 0.325
Altona oven			1	3	116	0.04 $\pm$ 0.239

Table 4: Constraints faced by fish smokers in the lagoon community

Smokers Constraints	Very serious	Moderate serious	Serious	Not serious	Mean
					X
High cost of fish smoking equipment	27	20	5	68	1.05
Losses caused by fish spoilage	70	42	3	5	2.48
Weather condition	9	81	10	20	1.66
Minor cut and scrapes during cutting of fish	102	8	5	5	2.73
Price fluctuation	25	75	20	0.0	2.04
Inadequate transport means	100	11	4	5	3.05
Falls injury	104	11		5	2.78
Eyes injury (Red eyes)	110	5	5	0.0	2.88

References

- Abolagba, O. J. and Odiko, A. E. (2005). Effect of charcoal from (*Pentacletramacrophllya*) and rubber (*Heveabrasillensis*) wood as energy sources on smoked Fish. Nigerian. *Journal of Aquatic and Appllied Science*, 45-49.
- Abolagba, O. J. and Chukwu, I. (2008). Socio-economic status of fish processors in Benin City metropolis, Nigeria. *Aquafield*, 4:33- 41.
- Adeyeye, S.A.O., Oyewole, O. B., Obadina, A. O., Omemu A. M., Oyedele, H. A., and Adeogun, S. O. A. (2015). A survey of traditional fish smoking and socio-economic status of the fish processors in Lagos State Nigeria, *African Journal of Food Sciences* 7: 21-33.
- Adeokun, O. A., Adereti, F. O. and Opele, A. I. (2006). Factors influencing the adoption of fisheries innovations by artisanal fishermen in coastal areas of Ogun State, Nigeria. *Journal of AppliedScience Research*, 2(11): 966-971.
- Akinwumi, F. O., Akinwumi, I. O. and Ogundahunsi, O. A. (2011). Characterization of artisanal fishery in the coastal area of Ondo State, Nigeria, *International Research Journal of Agricultural Science and Soil Science* 1(3): 41-42.
- Bolarinwa, I. F., Orfila, C., and Morgan, M. R. (2014). Amygdalin content of seeds, kernels and food products commercially-available in the UK. *Food chemistry*, 152, 133-139.
- Bonjoru, R., Ndeham, V. R., Bonjoru, F. H., and Amadu, S. O. (2019). Characterization and constraints of artisanal fishery in the upper Benue river basin, Nigeria. *International Journal of Fisheries and Aquatic Studies*, 7(3): 219-223.
- Fregene, B. T. and Bolorunduro, P. I. (2009). Role of Women in Food Security and Seasonal Variation of Expenditure Pattern in Coastal Fishing Communities in Lagos State. *Journal of Agricultural Extension*, 13 (2)21-33
- Odulate, D. O., George F. O. A, and Idowu A. A., (2014). Role of women in fisheries in coastal wetland areas of aquaculture production and management in Nigeria, *American Journal of Experimental Agriculture*, 4(10): 1137-1151.
- Oladimeji, Y. U. (2013). Analysis of Poverty and Welfare Measures among Artisanal Fishermen in Asa and Patigi Fishing Settlements of Kwara State. *Research Journal of Agricultural Sciences*, 4(5/6), 594-601.
- Olaoye, O. J., Odebiyi, O. C. and Abimbola, O. T. (2012). Hazards and injuries associated with fish processing in Nigeria. *Journal of Aquatic Science*, 3, No. 1, 1-5.
- Olaoye, O.J., Ojebiyi, W.G., Ogunremi, J.B., Oose, M.O., Ojeikhoa, O.R. and Opele, A.I. (2017).Some Hazardous Practices Associated with Artisanal Fish Processing inOgun Waterside Local Government Area of Ogun State, Nigeria. *Applied Tropical Agriculture*,22 (1) 68-77.
- Suleiman, A. Tosan and Fregene, B. T (2012). Analysis of costs and returns of artisanal fish marketing in Kebbi State, Nigeria, 62: 55-61.

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Mycotoxins and Mycotoxigenic Moulds in Feed and Fish: Implications on Aquaculture**Olajuyigbe O.O.**

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olaitan_afolabi@yahoo.com, +2348034271794**Abstract**

The rapid growth in the aquaculture industry and the high cost of feed necessitated the need to source for alternatives suitable for the production of good quality and affordable fish feed. However, the use of these “affordable” feed ingredients mainly of plant origin, has become a major concern in the aquaculture industry because most of these ingredients are susceptible to fungal growth and consequently mycotoxin contamination.

This article highlights some common mycotoxins in aquaculture, the effects of mycotoxin-contaminated feed on cultured fish and the need to increase research interest in this area. Thus, increasing awareness on the impact of mycotoxins on aquaculture and mitigate potential risks that mycotoxins could pose on the development of the industry.

Keywords: Mycotoxins, mycotoxigenic moulds, fish feed

Introduction

Aquaculture is one of the fastest growing food industry in Nigeria, with approximately a hundred percent increase in production between 2004 and 2007 (Falaye, 2013). The rise in production activities is as a result of the increasing awareness of the nutritional qualities that fish provide in the human diet. Hence, there is a need to satisfy the high demand for the provision of household fish consumed in Nigeria.

Mycotoxins are toxic metabolites produced by moulds. Their effects on animals and humans can be carcinogenic (e.g. aflatoxin B1, Ochratoxin A and *Fumonisin* B1), neurotoxic (*fumonisin* B1) nephrotoxic (Ochratoxin), dermatotoxic (Trichothecenes) or immunosuppressive (aflatoxin B1, ochratoxin A, and T.2 toxin) (CAST, 2003). A report by the Food and Agricultural Organization (FAO) in 2003 suggested that about 25% of food crops worldwide are susceptible to mycotoxin contamination.

A group of mycotoxins known as Aflatoxins are produced by *Aspergillus* spp mainly *Aspergillus flavus* and *Aspergillus parasiticum* and they pose a serious threat to animal and human health (Safwan *et al.*, 2019). Aflatoxins were first reported in 1960 and were responsible for the turkey “X disease” in England which led to the death of a lot of turkeys.

Feed and Feed Ingredients

Fish feed is the most expensive item in aquaculture, accounting for about 40- 50% of the production cost (Enyidi *et al.*, 2017). Fish meal which is mainly imported into the country at very expensive rates is majorly responsible for the high cost of fish feed. In order to reduce the high cost of feed, fish farmers usually substitute fish meal with other protein sources of plant origin.

Mycotoxins and Mycotoxigenic Moulds

Mycotoxins are toxic secondary metabolites produced by mycotoxigenic moulds. Mycotoxins are produced mainly by the genera *Aspergillus*, *Fusarium* and *Penicillium*. Mycotoxins are mostly produced in feed ingredients of plant origin, such as corn, groundnut, soybeans, cassava etc. Fungal contamination can then lead to mycotoxin production in the feed. Mycotoxins are therefore introduced into food and feed through the use of contaminated feed ingredients (Nacher-Mestre *et al.*, 2015). Animal by-products also serve as sources of mycotoxin contamination in feed (Volkel *et al.*, 2011). Consequently, mycotoxins have been recognised globally as feed and food safety issues, with different mycotoxin exhibiting different toxicological effects (Sofie *et al.*, 2010).

The common mycotoxins in feed ingredients include: Aflatoxin (mostly aflatoxin B1 (AFB1)), Deoxynivalenol (DON), Nivalenol (NIV), Zearalenone (ZEN), Ochratoxin A (OTA), T-2 toxin (t2), Fumonisin B1 (FB1), Moniliformin (MON), Enniatins (ENNs) and Beauvericin (BEA). The acceptable limits of some mycotoxins (e.g.

AFs, OTA, DON, ZEN and FBs) in agricultural commodities have been set by the European Union Commission Regulation 1881/2007 and its amendment (EU Commission Regulation, 2007). However only AFB1 is being regulated in feed (20 ug/kg in raw materials) (EU Commission Directive, 2003). Mycotoxin production by mycotoxigenic moulds depend on the mould's ability to produce certain chemical compounds as well as certain environmental factors (physical, chemical and biological) (Piotrowska *et al.*, 2013). Consumption of mycotoxin-contaminated feed by fish can lead to reduction in growth rate, immunosuppression, liver damage and increased mortality (Fallah *et al.*, 2014). In addition, it leads to accumulation of mycotoxins in the tissue of cultured fish thereby leading to the contamination of such products (Tolosa *et al.*, 2019).

Mycotoxins in the Muscle/ Tissue of Cultured Fish

Mycotoxigenic fungi and aflatoxins have been reported to be present in smoke-dried fish samples from Nigeria (Adebayo-Tayo *et al.*, 2008; Edema and Agbon 2010; Akinyemi *et al.*, 2012; Olajuyigbe *et al.*, 2014; Job *et al.*, 2015). Similarly, Orony *et al.* (2016) reported the presence of aflatoxins in dried fish from Kenya, while Farag *et al.* (2012) identified OTA and AFB1 in smoke-dried fish in Egypt. However, research findings have shown that moisture and salt concentration during processing influence the presence of these toxins in food products. Nevertheless, the factors that increase fungal growth include; quality of raw materials, processing methods, storage practices, temperature of the environment, humidity and moisture content of the finished product (Mahfouz and Sherif, 2015).

Aflatoxins are highly stable in nature. For instance, low levels of AFB2 (1.2ug/kg) have been detected in the muscles of dried fish stored at room temperature for three months (Sun *et al.* 2015). Fish consumption has also been linked with the presence of OTA in the food chain (Mortensen *et al.* 2014). Although, the toxicological effect is lower than that caused by consumption of cereal-based products, it may pose a risk to human consumers (Duarte *et al.*, 2012). This OTA has also been reported to be more stable in the environment than aflatoxins (Duarte *et al.*, 2010).

Fumonisin is a mycotoxin that rarely occurs in farmed fish, with previous studies indicating that no relevant toxin levels were detected in the muscle of DON- and ZEN-treated rainbow trout and common carp (Pietsch *et al.*, 2014, 2015; Woznyet *et al.*, 2015). Also, Nacher-Mestre *et al.* (2015) observed negligible toxin levels in the muscle of fish exposed to DON ≤ 79.2 ug/kg and fumonisins ≤ 754 ug/kg for approximately 8 months.

Risk Assessment

The risk assessment with the consumption of mycotoxin-contaminated food is estimated by calculating the Estimated Daily Intake (EDI) by assuming a human body weight of 60kg for an adult. The tolerable weekly intake (TWI) and tolerable daily intake (TDI) for different mycotoxins have been established by the Joint FAO/ WHO Expert Committee and Food Additives and Scientific Committee on Food. The tolerable intake levels are as follows:
 OTA: 120 ng/kg body weight (TWI)
 ZEN: 250 ng/kg body weight (TDI)
 T-2 + HT-2: 100 ng/kg body weight (TDI)
 DON: 1000 ng/kg body weight (TDI) (JECFA, 2001; ECSCF, 2002)
 Aflatoxins: No tolerable intake level

Consumption of mycotoxin contaminated fish is assumed to be risky if the amount of toxins in the product exceeds the tolerable intake level. However, the frequency of mycotoxin occurrence in fish products have not been adequately investigated.

Mycotoxins Research in Fish Feed in Nigeria

Studies on mycotoxin contamination in fish feeds have been carried out in most part of the developed nations, few have been reported in Sub-Saharan Africa (Bryden, 2012; Njobeh *et al.*, 2012; Marijani *et al.*, 2017), little or nothing has been done in Nigeria with regards to the effect of consumption of mycotoxin-contaminated feed on fish, despite the fact that our climate is favourable to the proliferation of mycotoxigenic fungi.

Conclusion

The impact of mycotoxins on fish health and on the fish consumers cannot be over emphasized. There is a need for continuous education and awareness creation on the need for good quality feed ingredients, adequate processing of feed and proper storage in order to reduce mycotoxin contamination in fish feeds and subsequently in the food chain.

There is also a need to carry out more research in order to generate data that can be used to analyse and assess the risks associated with consuming mycotoxin-contaminated feed and fish.

References

- Adebayo-Tayo B.C., Onilude A.A. and Patric U.G. 2008. Mycofloral of smoke-dried fishes sold in Uyo, Eastern Nigeria. *World Journal of Agricultural Sciences* 4: 23
- Akinyemi A.A., Adejola O.A., Obasa S.O. and Ezeri G.N.O. 2012. Aflatoxins in smoke-dried fish sold in Abeokuta, Ogun State, South-West Nigeria. *COLERM* 2: 478- 487.
- Bryden W.L. 2012. Mycotoxin contamination of the feed supply chain: Implications for animal productivity and feed security. *Feed Science and Technology* 173: 134-158.
- CAST Report (2003) Mycotoxins: risks in plant, animal, and human systems. In: Richard, J.L. and Payne, G.A. (Eds.), Council for Agricultural Science and Technology Task Force Report No. 139, Ames, Iowa, USA
- Edema M.O. and Agbon A.O. 2010. Significance of fungi associated with smoke-cured *Ethmalosafimbriata* and *Clariasgariepinus*. *Journal of Food Processing and Preservation* 34(S1): 355- 363.
- Enyidi U., Pirhonen J., Kettunen J., Vielma J. 2017. Effect of feed protein:lipid ratio on growth parameters of African catfish *Clariasgariepinus* after fish meal substitution in the diet with bambaranut (*Voandzeia subterranean*) meal and soybean (Glycine max) meal. *Fishes* 2,1. <http://dx.doi.org/10.3390/fishes2010001>
- European Committee Scientific Committee on Food. Opinion on Fusarium toxins. Part 6: Group evaluation of T-2 toxin, HT-2 toxin, nivalenol and deoxynivalenol. *European Commission* 2002; 1- 12. ECSCF
- European Commission. Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. *Off. J. Eur. Union* 2006, 364, 5–24. 16. Directive,
- E.U. Commission Directive 2003/100/EC of 31 October 2003 amending Annex I of Directive 2002/32/EC of the European Parliament and of the Council on undesirable substances in animal feed. *Off. J. Eur. Union* 2003, L285, 33–37.
- Falaye A.E. 2013. Fish: A jewel in land and sea environment. An Inaugural Lecture. University of Ibadan.
- Fallah A.A., Pirali-Kheirabadi E., Rahnama M., Saei-Dehkordi S.S. and Pirali-Kheirabadi K. 2014. Mycoflora, aflatoxigenic strains of *Aspergillus* section Flavi and aflatoxins in fish feed. *Quality Assurance and Safety of Crops And Foods* 6: 419- 424.
- FAO (Food and Agriculture Organization), Worldwide Regulations for Mycotoxins in Food and Feed in 2003, Information Division, FAO, Rome, 2003.
- Farag H.E.M., El-Taiby A.A. and Hassan H.M. 2012. Assessment of ochratoxin A and aflatoxin B1 levels in smoked fish with special reference to the moisture and sodium content. *Research Journal of Microbiology* 6(12): 813- 825.
- Job M., Agina S. and Dapiya H. 2015. Occurrence of aflatoxigenic fungi in smoke-dried fish sold in Jos Metropolis. *British Microbiology Research Journal* 11(1): 1- 7.
- Joint FAO/WHO Expert Committee on Food Additives (JECFA). Safety evaluation of certain mycotoxins in food. *WHO Food Addit.* 2001; Ser. 47
- Mahfouz M.E. and Sherif A.H. 2015. A multiparameter investigation into diverse effects of aflatoxin on *Oreochromis niloticus* health status. *Journal of Basic and Applied Zoology* 71: 48- 59.
- Marijani E., Wainaina J.M., Charo-Karisa H., Nzayisenga L., Munguti J., Gnonlonfin G. J. B., Kigadye E. and Okoth S. 2017. Mycofloral and mycotoxins in finished fish feed and feed ingredients from smallholder farms in East Africa. *Egyptian Journal of Aquatic Research* 43: 169-176.
- Nacher-Mestre J., Serrano R., Beltran E., Perez-Sanchez J., Silva J. and Karalazos V. 2015. Occurrence and potential transfer of mycotoxins in gilthead sea bream and Atlantic salmon by use of novel alternative feed ingredients. *Chemosphere* 128: 314- 320.
- Njobeh P.B., Dutton M.F., Aberg A.T., Haggblom P. 2012. Estimation of multi-mycotoxin contamination in South African compound feeds. *Toxins* 4: 836-848.
- Olajuyigbe O.O., Akande G.R., Ezekiel C.N. and Ezekiel M.O. 2014. Aflatoxigenic moulds and aflatoxin contamination of retailed fishery products in Lagos markets. *Mycotoxicology* 1: 57- 63.
- Orony D.N.A., Lalah J.O. and Jondiko I.O. 2016. Determination of carcinogenic polycyclic aromatic hydrocarbons (PAHs), aflatoxins and nitrosamines in processed fish from Winam Gulf area of Kenya and estimated potential exposure in human. *Polycyclic Aromatic Compounds* 36: 295- 317.
- Pietsch C., Michel C., Kersten S, Valenta H., Danicke S. and Schulz C. 2014. In vivo effects of deoxynivalenol (DON) on innate immune responses of carp (*Cyprinus carpio* L.). *Food Chemical Toxicology* 68: 44- 52.
- Pietsch C., Michel C., Kersten S, Valenta H., Danicke S. and Schulz C., Burkhardt-Holm P. 2015. Effects of dietary exposure to zearalenone (ZEN) on carp (*Cyprinus carpio* L.). *Toxins* 7(9): 3465- 3480).

- Piotrowska M., Slizewska K., and Biernasiak J. 2013. Mycototoxins in cereals and soybean-based food and feed, soybean- Pest Resistance. In: El-Shemy H.A. Editot. IntechOpen; February 13th. DOI: 10.5772/54470.
- Safwan A.A.M., Bacha N. and Alharazi T. 2019. Detection of total aflatoxins in groundnut and soybean samples in Yemen using enzyme-linked immunosorbent assay, *Journal of Food Quality* 1: 7-18.
- Sofie M., Van Poucke C., Detavernier C., Dumoult F., Van Velde M.D.E., Van Dyck S., Averkieva O., Van Peteghem C. and De Saeger S. 2010. Occurrence of mycotoxins in feed as analysed by a multi-mycotoxin LC-MS/MS method. *Journal of Agriculture and Food Chemistry* 58: 66-71.
- Sun W., Han Z., Aerts J., Nie D., Jin M. and Shi W. 2015. A reliable liquid chromatography-tandem mass spectrometry method for simultaneous determination of multiple mycotoxins in fresh fish and dried seafoods. *Journal of Chromatography*. 1387: 42- 48.
- Tolosa J., Barba F.J., Font G. and Ferrer E. 2019. Mycotoxin incidence in some fish products: QuEChERS methodology and liquid chromatography linear ion trap mass spectrometry approach. *Molecules* 2019, 24: 527-542
- Volkel I., Schroer-Merker E., and Czerny C.P. 2011. The carry-over of mycotoxins in products of animal origin with special regard to its implications for the European food safety legislation. *Food Nutrition Science* 2: 852-867.
- Wozny M., Dobosz S., Obremski K., Hliwa P., Gomulka P. and Lakomiak A. 2015. Feed-borne exposure to zearalenone leads to advanced ovarian development and limited histopathological changes in the liver of premarket size rainbow trout. *Aquaculture* 448: 71-81.

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Proximate Composition and Nutritional Status of a Claroteid/Catfish (*Chrysichthys nigrodigitatus*) Processed Fresh, Oven-Dried and Frozen in Uyo, Akwa Ibom State, Nigeria

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Abstract

Study on the proximate composition and nutritional status of a Claroteid catfish (*C. nigrodigitatus*) processed fresh, oven-dried and frozen was conducted using standard procedures. 45 fish were shared into three groups. Each group was used for fresh, oven-dried and frozen determination respectively. Electric oven was adopted for drying at 65-70°C while freezing was achieved in laboratory freezer for two weeks. Fresh samples were not subjected to any processing methods. Samples were beheaded, eviscerated and mucous removed gently by scrubbing with knife. Proximate composition, mineral elements and vitamin contents of the three sample groups were determined. Mean results of proximate composition were found to contain: caloric value (Kcal) - fresh (105.82±5.221), oven-dried (376.077±0.280) and frozen (103.53±6.336); %protein - fresh (21.42±0.221), oven-dried (61.020±0.728) and frozen (16.19±0.09); %ash - fresh (1.32±0.061), oven-dried (12.95±0.026) and frozen (1.28±0.021); %lipid - fresh (1.59±0.0372), oven-dried (11.24±0.006) and frozen (2.76±0.003); %fibre - fresh (0.899±0.027), oven-dried (7.80±0.085) and frozen (0.84±0.15); as well as %carbohydrate - fresh (1.460±0.257), oven-dried (7.72±0.694) and frozen (2.48±0.147). %moisture was 73.60±0.790 and 76.45±0.146 in fresh and frozen samples respectively. Statistical analysis (ANOVA) on the proximate composition showed that the samples were not significantly different from each other ($P>0.05$). Vitamin A (mg/100g) was detected as 1.427±0.02 in fresh, 6.126±0.1 in oven-dried and 1.43±0.02 in frozen while vitamin C was observed as 9.178±0.04 in fresh, 16.461±0.06 in oven-dried and 9.217±0.08 in frozen samples. Again, ANOVA on the vitamin composition of the samples showed no significant difference ($P>0.05$). The mineral elements were detected in the following order: fresh = Mn>Ca>Mg>Na>P>Zn>K>Fe>Cu; oven-dried = Mn>Cu>Ca>P>Mg>Zn>Na>Fe>K and frozen = Mn>Ca>P>Mg>Na>Zn>K>Fe>Cu. Mn content was highest in all the samples while Cu was the least in frozen and fresh samples. Statistical analysis on the elements showed that the samples were significantly different ($P<0.05$). The results of this study propose that oven-dried sample contains higher nutrients than fresh and frozen. This therefore means that drying and freezing methods have an effect on the proximate composition and nutritional status of catfish. Dried fish is preferably recommended for healthy and nutritional consumption.

Keywords: Proximate composition, Vitamins, Minerals, *Chrysichthys nigrodigitatus*

Introduction

Fish is the major source of protein for most Nigerians. The increasing human population and the desire to obtain a nutritionally balanced level of protein intake is a major cause of the high fish demand in Nigeria (Olaleye, 2015). Fish is a highly perishable commodity and must be processed to avoid spoilage, shortage and other economic losses (Okonta and Ekelemu, 2005). The methods of fish processing include freezing, smoking, drying and heat treatment (sterilization, pasteurization, etc.). Smoking and freezing are the most common methods used by fish processors in Nigeria. Although fish is a good source of some essential nutrients, processing and processing practices could cause modifications in proximate composition, fatty acids and amino acids as well as changes in the nutrient quality of fish and trace metal composition (Castrillon *et al.*, 1997). The nutritional status of fish can be estimated by determining its proximate composition such as crude protein, lipid profile, ash content, crude fibre, carbohydrates/nitrogen free extract (NFE), energy value and other nutrients like vitamins and mineral elements, which are important in ensuring that such a fish is within the range of dietary requirement and commercial specification (Watchman, 2000). *Chrysichthys nigrodigitatus* (Claroteid catfish) is an important species of fresh water fish in Nigeria. The fish is palatable and popular and is widely consumed in many parts of the country, contributing to the local fishery and improving the socio-economic growth of the area. The fish is commercially available as dried, fresh or as frozen fish. There are some indications that frozen and dried food seems to affect some vital nutrient compositions but this hypothesis has not been scientifically proven for *C. nigrodigitatus*. The result of this research will therefore provide answers to this problem by evaluating the effect of heat treatment and prolonged ice storage on the proximate composition and the nutritional status of the fish.

Materials and Methods

Sample collection, preparation and processing

A total of forty-five (45) fresh adult fish samples (*C. nigrodigitatus*) were randomly selected and purchased from a nearby market. The samples were preserved in a cooler containing ice block and transported to the biochemistry laboratory for analysis. The samples were shared into three equal parts (i.e. 15 fish per group). Each portion was used for separate determination namely: fresh, oven-dried and frozen analysis. The samples were beheaded and eviscerated, mucous on the samples were also removed as part of the preparation procedures. Only the edible portion of the fish was used for analysis. Drying was achieved in the laboratory using an electric oven at a regulated temperature of 65-70°C, while freezing was carried out in laboratory freezer for two weeks before analysis. Fresh fish analysis was carried out immediately the samples arrived at the laboratory. They were not subjected to any processing methods.

Determination of proximate composition and mineral content

The sample (*C. nigrodigitatus*) was analyzed for its proximate composition using the standard methods of (AOAC, 2005). The moisture content was determined by heating 2.0g each of sample to a constant weight in a crucible placed in an oven maintained at 105°C. The ash content was determined by incinerating 1.0g of the fish sample in a muffle furnace maintained at 550°C for 5 hours. Crude ash measurement is a function of the mineral element constituents in the sample. Crude fat was obtained by exhaustively extracting 5.0g of each sample in soxhlet apparatus using petroleum ether (40-60 °C) as extracting reagent. The crude fibre was determined by acid–base digestion using 1.25% H₂SO₄ and 1.25% NaOH solution. The procedure involves digesting a known quantity of sample in H₂SO₄ for 30 minutes, filtration and collection of the residue, digesting the residue in NaOH, filtration and drying of the residue in an oven before ignition in the furnace. (Antia *et al.*, 2006). The crude protein (% total nitrogen x 6.25) was determined by the micro-Kjeldahl method. Mineral element compositions were determined by atomic absorption spectrophotometry (AAS) and flame photometry. Sodium (Na) and Potassium (K) were determined by direct aspiration of sample solution using flame analyzer while other metals such as Ca, Mg, Fe, Zn, P, Mn and Cu were determined by AAS (AOAC, 2005).

Determination of vitamin composition

The vitamin A and C content of the fish as indicated in this study was measured using standard spectrophotometric methods as described by AOAC, 2005.

Results

The mean results (triplicate trials) of the proximate composition of fresh, oven-dried and frozen samples of *C. nigrodigitatus* shown in Table 1 below. Statistical analysis (ANOVA) on the samples was not significantly different at 0.05 confidence level ($P > 0.05$).

Table 1: Result of the Proximate Composition (%) of Fresh, Oven-dried and Frozen *C. nigrodigitatus*

Sample Id	Fresh	Oven-dried Fish	Frozen Fish
Moisture (%)	73.60±0.790	-	76.45±0.146
Ash (%)	1.32±0.061	12.95±0.026	1.28±0.021
Fibre (%)	0.90±0.027	7.80±0.085	0.84±0.015
Protein (%)	21.42±0.221	61.02±0.728	16.19±0.090
Lipid (%)	1.59±0.372	11.24±0.006	2.76±0.003
Carbohydrate (%)	1.46±0.257	7.72±0.694	2.48±0.147
Caloric Value (Kcal)	105.82±5.221	376.08±0.280	103.53±6.336

Mean ± SD of 3 Determinations

The data on Table 2 shows the mean results (in triplicate trials) of the mineral element composition of fresh, oven-dried and frozen samples of *C. nigrodigitatus*. Statistical analysis (ANOVA) of the data shows that the mineral elements of the three samples were significantly different at 0.05 confidence level ($P < 0.05$). These results reveal that this fish is a good source of both macro and micro mineral nutrients. The data at a glance entails that drying promotes and increases the mineral composition of the fish when compared with the fresh sample. Also, there is an increase in the frozen sample in all the mineral elements except Na, Mn and Cu which show a slight decrease when compared with the fresh sample. Mn content is the highest in all the samples while Cu is the least in fresh and frozen samples. The finding also indicates that Cu content increases during drying. The order of the elemental composition

of *C. nigrodigitatus* is given as; Fresh Sample = Mn>Ca>Mg>Na>P>Zn>K>Fe>Cu, Oven-dried Sample = Mn>Cu>Ca>P>Mg>Zn>Na>Fe>K and Frozen Sample = Mn>Ca>P>Mg>Na>Zn>K>Fe>Cu. The level of vitamin composition of *C. nigrodigitatus* processed fresh, oven-dried and frozen. Statistical analysis (ANOVA) of the data indicates that the samples are not significantly different at 0.05 confidence level. Moreover, these results also propose that the fish contains more Vitamin C than vitamin A and that the oven-dried sample maintains the highest level of these two vitamins.

Table 2: Result of mineral element and vitamin content (mg/100g) of Fresh, Oven-dried and Frozen *C. nigrodigitatus*.

Sample Id	Fresh Fish	Oven-dried Fish	Frozen Fish
Ca	2.854±0.013	5.710±0.002	2.731±0.002
Mg	2.09±0.001	3.117±0.003	1.963±0.002
Fe	0.183±0.003	1.402±0.003	0.204±0.003
Na	1.885±0.005	2.163±0.002	1.644±0.001
K	0.922±0.003	1.129±0.002	0.928±0.015
Zn	1.338±0.002	2.614±0.002	1.381±0.003
P	1.731±0.003	3.660±0.000	2.111±0.002
Mn	4.954±0.010	9.180±0.003	4.045±0.063
Cu	0.011±0.020	6.074±0.003	0.010±0.001
Vitamin A	1.427±0.02	6.126±0.01	1.430±0.02
Vitamin C	9.178±0.04	16.461±0.06	9.217±0.08

Mean ± SD of 3 determinations

Discussion

The moisture content of the fresh sample (73.60±0.790) in this study is almost similar to 72.53±0.23% reported by Keremah and Amakiri, (2012) with *Heterobranchius bidorsalis* although, Olayemi *et al.*, (2011) reported a higher value of moisture content in fresh *Clarias gariepinus*. The knowledge of the moisture content of food stuff usually serves as an index of stability and susceptibility to microbial infection. Hence, the greater the moisture content the shorter the shelf-life and vice versa. Therefore, low moisture content is of great value in the preservation of food stuff (Edem *et al.*, 1985). The ash content which reflects the mineral element composition as observed in this study in fresh sample (1.32±0.061%) is consistent with the range (1.35 – 5.88%) reported by Effiong and Fakunle, (2011). However, processing methods that is, drying and freezing have affected the level of this parameter. Drying caused an increase in the ash content (12.95±0.26%) when compared with the fresh sample. Also, the value of the frozen sample (1.28±0.021%) is lower than the fresh counterpart. The fiber content of the fresh sample (0.899±0.027%) as provided in this study is almost similar to the value reported by Chukwu and Shaba, (2009) with *Clarias gariepinus* (0.98±0.01%). Drying increased the fiber content when compared with the fresh sample. The value of oven-dried sample (7.80±0.085%) is higher than the one proposed by Effiong and Mohammed, (2008), as well as Chukwu and Shaba, (2009). Again, the value of the frozen sample (0.84±0.015%) is slightly lower than that of the fresh sample. This value is within the range proposed by Effiong and Fakunle (2011). The crude protein content of the fresh fish (21.42±0.221%) in this research compares favorably with the values obtained by Keremah and Amakiri (2012) who reported 21.37±0.13% with *C. nigrodigitatus* but slightly lower than that of Udo and Arazu (2011). This is similar to the result obtained in this study with the fresh sample. The oven-dried sample (61.02±0.72%) is higher than that of the fresh sample. This is in accordance with the finding of Olayemi *et al.*, (2011). The frozen fish (16.19±0.09%) indicates a lower value when compared with the fresh sample. This observation agrees with the range reported by Udo and Arazu, (2011). The fat (lipid) content of the fresh fish (1.59±0.221%) obtained in this research is lower than that reported by Keremah and Amakiri, (2012). Comparing the result of the lipid content of the oven-dried (11.24±0.006%) and frozen fish (2.76±0.003%) with that of the fresh sample, it is important to note that these methods of processing have caused an increase in the lipid composition. The reason is the fact that fat may exude with the moisture evaporation and extended heat treatment. Drying seems to enhance this phenomenon. This result is consistent with the work of Chukwu and Shaba (2009), who reported that drying methods caused an increase in the lipid content of *Clarias gariepinus*. On the hand, this result is contrary to the one provided by Saliu (2008), who proposed that frozen storage leads to a reduction in fat composition of fishes. Fat content in an animal's body is highly variable and this could affect the level of other constituents especially water. This was evident in the observed crude fat levels by Effiong and Tofa (2006). The value obtained in this study with the fresh fish sample

(1.460±0.257%) is consistent with the range (1.33±0.19 – 2.55±0.19%) reported by Keremah and Amakiri (2012) and Effiong and Fakunle (2011) reported the range (1.50 – 13.34%) in which this work upholds. Comparing the result of the carbohydrate of the fresh sample with the oven-dried sample (7.72±0.694%) and the frozen sample (2.48±0.147%), it could be noted that the effect of these processing methods resulted in an increase in the level of the nutrient. This finding is in agreement with the work of Olayemi *et al.*, (2011), who observed that drying leads to an increase in the carbohydrate level of *Clarias gariepinus* fish. The caloric value depicts the energy value of the fish. This study observed that the caloric value of the oven-dry sample (376.077 ± 0.280 kcal) was higher when compared with the fresh sample (105.82 ± 5.221 kcal) as well as the frozen sample (103.53 ± 6.336 kcal). The value of the frozen fish was lower when compared with the result reported by Udo and Arazu (2011). These differences may be attributed to the differences in the method of processing and the effect of each processing method on nutrient.

The data on Table 2 reveals that *C. nigrodigitatus* is a good source of Manganese. The oven-dried sample has the highest value (9.180±0.003mg/100g), followed by the fresh sample (4.954±0.010mg/100g) while the frozen sample contains the least (4.045±0.063mg/100g). This variation may be due to the method of processing. The oven-dried sample contains the highest level of Calcium (5.710±0.02mg/100g), followed by the fresh sample (2.854±0.013mg/100g) while the frozen sample (2.731±0.002mg/100g) has the lowest. The oven-dried sample contains the highest Mg (3.117±0.003mg/100g), followed by the fresh sample (2.09±0.001mg/100g) while the frozen sample (1.963±0.002mg/100g) has the lowest. The oven-dried sample (2.163±0.002mg/100g) contains the highest value of sodium, followed by the fresh sample (1.885±0.005mg/100g) while frozen sample (1.644±0.001mg/100g) contains the lowest level. The oven-dried sample (3.660±0.000mg/100g) contains the highest of phosphorus, followed by the frozen sample (2.111±0.002mg/100g) and the lowest was found in the fresh sample (1.731±0.003mg/100g). This finding agrees with the result of Chukwu and Shaba (2009). They reported that phosphorus level increases significantly in processed samples. The highest level of potassium was found in the oven-dried sample (1.129±0.002mg/100g). This finding also reports that the potassium content of the fresh fish (0.922±0.003mg/100g) and the frozen sample (0.928±0.015mg/100g) is almost similar. The highest level of Zinc was found in the oven-dried sample (2.614±0.002mg/100g) while the fresh sample content (1.338±0.002mg/100g) was almost similar to the frozen sample (1.381±0.003mg/100g). This value is higher than the range (0.042-0.084mg) proposed by Effiong and Fakunle (2011) for fresh fish. The highest level of iron was found in the oven-dried sample (0.204±0.003mg/100g) while the fresh sample (0.183±0.003mg/100g) was found to contain the lowest. The value is higher than the range (0.014-0.086mg) reported by Effiong and Fakunle (2011) for fresh fish. The level of Cu was found lowest in the fresh sample (0.001±0.020mg/100g) and frozen sample (0.010±0.001mg/100g) when compared with all the mineral elements of the fish. This finding also observes that the level of Cu was promoted in the oven-dried sample (6.074±0.003mg/100g). The highest level of vitamin A was found in the oven-dried sample (6.126±0.01mg/100g). The value of the fresh sample (1.427±0.02mg/100g) was observed almost similar to that of the frozen sample (1.430±0.02mg/100g). This finding corresponds with the result reported by Chukwu and Shaba (2009). They observed that increase in vitamin A content was one of the prominent changes in catfish after drying. The oven-dried sample (16.461±0.06mg/100g) maintained the highest level of vitamin C. There was a reduction in the frozen sample (9.217±0.08mg/100g) and the fresh sample (9.178±0.04mg/100g) when compared with the fresh sample. Chukwu and Shaba (2009) reported a lower value in dried *Clarias gariepinus*.

Recommendations

Based on the results of this study, it is recommended that *C. nigrodigitatus* be used as a source of alternative animal protein because it is rich in chemical nutrients. Dried fish is preferably recommended for healthy and nutritional consumption.

References

- Antia, B. S., Akpan, E. J., Okon, P. A. and Umoren, I. U. (2006). Nutritive and Anti-nutritive Evaluation of Sweet Potato (*Ipomea batatas*) Leaves. *Pak. J. Nutr.*, 5: 166-168.
- AOAC (2005). *Official Methods of Analysis of International*, 17th Edn. 1st Revision, Gaithersburg, MD, USA, Association of Analytical community.
- Castrillon, A. M., Navarro, P. and Alvarez-fontes, E. (1997). Changes in Chemical Composition and Nutritional Quality of Fried Sardine *Clupea Pilchardus* Produced by Frozen Storage and Microwave Reheating. *J Sci Food Agric*, 75(1): 125-32.
- Chukwu, O. and Shaba, I. M. (2009). Effects of Drying Methods on Proximate Composition of Catfish (*Clarias gariepinus*). *World Journal of Agricultural Sciences*, 5(1): 144-116.

- Edem, D. O., Eka, O. U. and Ifon, E. T. (1985). *Studies on the Nutritive Value of the Seed of Treculia africana (African Bread Fruit tree)*. M.Sc. Thesis, University of Calabar, Nigeria.
- Effiong, B. N. and Fakunle, J. O. (2011). Proximate and Mineral Composition of some Commercially Imported Fishes in Lake kainji, Nigeria. *Journal of Basic and Applied Scientific Research*, 1(12): 2497-2500.
- Effiong, B. N. and Mohammed, I. (2008). Effect of Seasonal Variation on the Nutrient Composition in Selected Fish Species in lake kainji, Nigeria. *Nature and science*, 6(2): 1545-0740.
- Effiong, B. N. and Tofa, J. L. (2006). Proximate Composition of Nutrients in Adult *Clarias gariepinus*, *Heterobranchus longifilis*, and their Hybrid (Heteroclarias). In: Ansa, E. J., Anyankwu, P. E., Ayonoadu, B. W., Erundu, E. S. and Deekae, S. N. (Eds). Proc. of 20th Annual Conf. of FISON, Port-Harcourt, 14th-18th Nov., 2005. PP. 550-553.
- Keremah, R. I. and Amakiri, G. (2013). Proximate Composition of nutrients in Fresh Adult Catfish (*Chrysichthys nigrodigitatus*, *Herobranchus bidorsalis* and *Clarias gariepinus*) in Yengoa, Nigeria. *Greener Journal of Agricultural sciences*, 3(4): 291-294.
- Okonta, A. A. and Ekelemu, J. K. (2005). A Preliminary Study of Micro-organisms Associated with Fish Spoilage in Asaba, Southern Nigeria. Proceedings of the 20th Annual Conference of the Fisheries Society of Nigeria (FISON), Port Harcourt, Pp. 557-560.
- Olaleye I.G (2015) Effects of Grasshopper Meal in the Diet of *Clarias Gariepinus* Fingerlings. *Journal of Aquaculture Research and Development* 6: 321.
- Olayemi, F. F., Adedayo, M. R., Bamishaiye, E. I. and Awagu, E. F. (2011). Proximate Composition of Catfish (*Clarias gariepinus*) Smoked in Nigerian Stored Products Research Institute (NSPRI): Developed Klin. *International Journal of Fisheries and Aquaculture*, 3(5): 96-98.
- Saliu, J. K. (2008). Effect of Smoking and Frozen Storage on the Nutrient Composition of Some African Fish. *Advances in Natural and Applied Sciences*, 2(1): 16-20.
- Udo, P. J. and Arazu, V. N. (2011). The Biochemical Composition of Three Exotic Fish Delicacies: *Scomberscombrus*, *Trachurustrachurus* and *Sardinapilchardus* Frozen and Imported into Nigeria. *Pakistan Journal of Nutrition*, 10(12): 1158-1162.
- Watchman, I. I. (2000). Composition and Quality of Fish, Edinburgh. Tory Research Station.

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Evaluation of Organ Indices of *Clarias gariepinus* (Burchell, 1882) Fed With Sweet Potato (*Ipomoea batatas*) Leaf Meal

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Abstract

Four hundred *Clarias gariepinus* were fed with five diets of 35% crude protein containing 0, 2.5, 5.0, 7.5 and 10 % Sweet potato leaf meal (SPLM) respectively for 8 weeks. This study was carried out to measure and determine the condition of *C. gariepinus* fed with Sweet potato leaf meal by using viscerosomatic, hepatosomatic and gonadosomatic indices. Sweet potato leaf meal substituted fish meal at 0% (control), 2.5% and 5.0%, 7.5% and 10% in the five different diets. A total of 400 *C. gariepinus* fingerlings (mean weight 9.60 ± 0.06) were randomly distributed into twenty plastic aquaria tanks at 20 fish per tank in triplicate and were fed twice daily at 9.00 hrs and 17.00 hrs for 8 weeks. There was significant difference $p < 0.05$ in viscerosomatic index (VSI) value of fish fed control diets T1 compared with other diets with Sweet potato leaf meal inclusion at 2.5, 5.0, 7.5 and 10%. There was no significant difference ($p < 0.05$) in the hepatosomatic index (HSI) in the fish fed with diet T1 to T5. There was no significant difference in gonadosomatic index value of fish fed control diets T1 compared with other treatments T2, T3 and T4. The results of this study have demonstrated that fish meal can be replaced by sweet potato leaf meal in African catfish diets up to 2.5 – 7.5% rate without negatively affecting the liver, intestine and gonad.

Keywords: *Clarias gariepinus*, Viscerosomatic index, Hepatosomatic index, and Gonadosomatic index

Introduction

Fish serves as a source of food and income for most people in the developing countries particularly Africa (FAO, 1996). Nutritionally, fish is equivalent to meat in protein with a good amino acid profile, high essential mineral element and low saturated fatty acid (Boylston, 2012). High cost of animal protein ingredients for fish feed production has been a major challenge to the development of aquaculture in Nigeria. This has resulted to increasing cost of fish production and consequently increase in the cost of fish products, hence fish nutritionist all over the world are researching into developing dietary protein source in which fish will maximize growth and increase production within the shortest possible time and at the lowest cost (Adewolu, 2008). A number of plants continue to be evaluated for their potential in substituting or totally replacing fish meal in the diet of fish.

Leaf meal is one of the cheapest source of protein that may reduce the cost of fish feed. Sweet potato (*Ipomoea batatas*) is a dicotyledonous plant which belongs to the family Convolvulaceae (Austin, 1988). It is an herbaceous creeping plant with smooth, lightly moderate green leaves sometimes with a considerable amount of purple pigmentation especially along its veins (Longe, 1986). Sweet potato grows best at an average temperature of 24° C (75° F) with abundant sunshine and warm nights. Annual rainfall of 750-1000mm is considered most suitable with a minimum of 500mm in the growing season (Austin, 1988). It is cultivated in over 100 nations and ranks fifth among the most important food crops in the tropical areas (An, 2004). According to Hong (2003), sweet potato is a major tropical crop with a short and fast growth cycle. Sweet Potato leaves has 4.90% Crude fat; 24.85% Crude protein; 51.95% Carbohydrate; 7.20 % Crude fiber; Caloric value 351.30 ME kcal / g. (Antia *et al*, 2006). Leaves of sweet potato (*Ipomoea batatas*) have high crude protein (CP) content ranging from 25% to 29% in DM (Hong *et al*, 2003), with high amino acid score. Besides from its nutritive values, sweet potato leaves can be harvested many times throughout the year (Hong *et al*, 2003) thereby making the leaf meal to be abundant. Hence this study was carried out to determine the effect of sweet potato (*Ipomoea batatas*) leaf meal (SPLM) on the size liver, intestine and gonad of African catfish (*Clarias gariepinus*).

Organ indices have been used as indicators of change in nutritional and energy status of fish (Adams *et al.*, 1996). Commonly used organ indices include: hepatosomatic index (HSI), viscerosomatic index (VSI), spleenosomatic index (SSI) and gonadosomatic index (GSI). The feeding habit of *C. gariepinus* has been shown to be an omnivore (Olojo *et al.*, 2005). Fish is known to quickly change morphology to variation in habitats and food availability

(Olsson *et al.*, 2007). Hence, this study was carried out to determine the effect of sweet potato (*Ipomoea batatas*) leaf meal (SPLM) on this selected organ indices.

Materials and methods

Study location:

The study conducted at the fish nutrition experimental units of the Department of Biotechnology, Nigerian Institute for Oceanography and Marine Research, (NIOMR) Victoria Island, Lagos Nigeria.

Sources of ingredients and diets preparation:

White maize, Soya beans, and Groundnut cake were obtained locally from the market and milled, while Fish meal, Vitamin premix, Vegetable oil, Vitamin C and Antimould were obtained from the feed mill factory, Badore NIOMR. Sweet potato leaves were freshly plucked from their branches at International Institute of Tropical Agriculture (IITA), Ibadan, Oyo state, dried under room temperature for 3 weeks until it became crispy to touch after which they were milled.

Formulation of experimental diets:

Five isonitrogenous diets of 35% crude protein were formulated to contain 0%, 2.5%, 5.0%, 7.5% and 10% sweet potato leaf meal to partially replace 18% fish meal in 100% formulated diets of *Clarias gariepinus*. Sweet potato leaf meal and other ingredients were mixed thoroughly with oil, processed into a paste by adding hot water and pelleted through a metal plate with a die of 2.0mm. The resulting pellets were air-dried after which they were packed into an air tight container prior to the start of the experiment.

Feeding trials

A total of 300 *Clarias gariepinus* fingerlings of a mean average weight of 9.06 ± 0.02 were randomly allotted at the rate of 20 fingerlings per tank into each of the 15 experimental plastic tanks. The fish were acclimatized for two weeks prior to the start of the experiment. The fish were fed twice daily at 3% body weight throughout the experiment. The ration was adjusted every two weeks after new weight of the fish has been determined.

Data and analysis

At the end of the trial, gonadosomatic index (GSI), hepatosomatic index (HSI) and viscerosomatic index (VSI) were calculated.

$$(GSI) = \frac{\text{Gonad weight (g)}}{\text{Fish weight (g)}} \times 100$$

Fish weight (g)

To determine HSI, liver weight were determined using the formular:

$$HSI (\%) = \frac{\text{liver weight (g)}}{\text{Fish weight (g)}} \times 100$$

Similarly, viscera weight also recorded to the nearest mg and VSI determined using the formular:

$$VSI (\%) = \frac{\text{viscera weight (g)}}{\text{Fish weight (g)}} \times 100$$

Fish weight (g). All the result were subjected to analysis of variance (ANOVA). Duncan multiple range test was further used to evaluate the means differences at 0.05 significant levels.

Table1. Gross composition of experimental Diets

Ingredients	Sweet Potato Leaves meal inclusion %				
	0	2.5	5	7.5	10
Fish meal	18.00	15.50	13	11.50	8.00
SPLM	0.00	2.50	5.00	7.50	10.00
SBM	26.00	27.50	30.00	33.00	35.00
GNC	20.00	20.50	22.00	23.00	25.00
Corn	32.30	30.30	26.30	22.30	18.30
Vitamin premix	0.50	0.50	0.50	0.50	0.50
Vegetable oil	2.50	2.50	2.50	2.50	2.50
Vitamin C	0.50	0.50	0.50	0.50	0.50
Antimould	0.20	0.20	0.20	0.20	0.20
Total	100	100	100	100	100

Key: SPLM sweet potato Leaf Meal, SBM Soya Bean Meal

Table2. Organ indices of *Clarias gariepinus* Fed Sweet Potato leaf meal.

Parameters	Sweet Potato Leaves meal inclusion %				
	T1 (0)	T2 (2.5)	T3 (5)	T4 (7.5)	T5 (10)
Viscerosomatic index	2.06±0.21 ^a	1.41±0.19 ^{ab}	1.52±0.14 ^{ab}	0.99±0.23 ^{ab}	0.95±0.26 ^b
Hepatosomatic index	0.97±0.68 ^a	0.20±0.08 ^a	0.29±0.08 ^a	0.18±0.04 ^a	0.15±0.03 ^a
Gonadosomatic index	0.76±0.12 ^a	0.56±0.11 ^a	0.66±0.05 ^a	0.54±0.06 ^a	0.28±0.01 ^b

Results and discussion

The effect of different levels substitution of fishmeal with sweet potato leaf meal on viscerosomatic index (VSI), hepatosomatic index, gonadosomatic index of the *Clarias gariepinus* fingerlings is represented in Table 2. The highest Viscerosomatic index (VSI) value of 2.06 was recorded in the fish fed with control diet T1, which contain 18% fishmeal, while the least value of 0.95 was recorded in fish fed diet T5 with 10% sweet potato leaf meal inclusion. There were significant different $p < 0.05$ in viscerosomatic index (VSI) value of fish fed control diets T1 compared with other treatments T2,T3,T4 and T5 with varying inclusion level of sweet potato leaf, the low VSI observed in fish fed SPLM may be related to low nutrients deposition in organs of fish fed plant-based diet, suggesting a state of insufficient reserves of energy and nutrients. Similar phenomena was found on tongue sole *Cynoglossus semilaevis* (Dai *et al.*, 2016) when this fish fed plant-based diet.

There were no significant different ($p > 0.05$) in the Hepatosomatic index (HSI) in the fish fed with diet T1 to T5, this indicates that there were no abnormal increase in size of liver due to the absence of contaminant in sweet potato leaf meal, this report is in contrast to the report by Sadekarpawar and Parikh, (2013) who reported that exposure of liver to contaminants can lead to an increase in liver size in fishes. The highest gonadosomatic index (GSI) of 0.76 was recorded in the fish fed with control diet T1 while the least value of 0.28 was recorded in the fish fed T5 with 10% sweet potato leaf meal inclusion. There were no significant different $p < 0.05$ in gonadosomatic index value of fish fed control diets T1 compared with other treatments T2,T3 and T4 with varying inclusion level of sweet potato leaf meal but treatment T5 differ significantly $p < 0.5$ from control diet T1. These suggested that at 2.5%, 5%, and 7.5% substitution levels of fishmeal with sweet potato leaf meal, the gonad development are not affected but at higher levels up to 10% and above of sweet potato leaf meal substitution will significantly reduce gonad development thereby lowering the reproductive potential of catfish, this is in agreement with the report by Shim *et al.*, (1989) that quantity and quality of protein in the diet affect the reproductive performance of different species of fish.

Conclusion

The results of this study have demonstrated that fish meal can be replaced by Sweet potato meal in African catfish diets up to 2.5 – 7.5% rate without negatively affecting the liver and gonadal development. Therefore, from this study the recommended substitution levels of fishmeal with sweet potato leaf meal is between 2.5 – 7.5%, at higher levels up to 10% and above will significantly reduce gonad development thereby lowering the reproductive potential of catfish.

References

- Adams, S.M., Ham, K. D., Greley. M. S., Le, Hew. Hinton, D. E. and Saylor. C. F.(1996).Downstream gradients in bio indicator responses.*Journal of aquatic science*. 53: 2177-2187.
- Adewolu, M.A. (2008). Potentials of Sweet Potato (*Ipomoea batatas*) Leaf Meal as Dietary *Ingredient for Tilapia zilli Fingerlings*, *Pakistan J. of Nutrition* 7(3), Pp 444 – 449
- An, L.V. (2004). Sweet potato leaves for growing pigs: Biomass yield, digestion and nutritive value. PhD thesis, *Swedish University of Agriculture Sciences*, Pp 49.
- Antia, B.S., E.J. Akpan, P.A. Okon and Umoren I.U. (2006). Nutritive and Anti-Nutritive Evaluation of sweet potatoes (*Ipomoea batatas*) Leaves. *Pakistan Journal of Nutrition* 5 (2): Pp 166-168.
- Austin, D.F. (1988). The taxonomy, evolution and genetic diversity of sweet potatoes and related wild species In: P. Gregory (ed.). *Exploration,Maintenance and Utilization of Sweet potato Genetic Resources CIP*, Lima, Peru.Pp 27-60
- Boylston, T., Chen, F., Cggins, P., Hydlig, G., McKee, L.H., and Kerth, C.(2012). “*Handbook of meat, poultry and seafood quality*”.
- Dai W., Mai KTN., Xu W., Zhang Y., Xu D, Ai Q.,(2016). Effects of replacing fish meal with plant-based protein on growth, physiological and biological indices, and intestinal histology in tongue sole, *Cynoglossus semilaevis* Güntuer. *Journal of Fishery Sciences of China*;16(1):1125–1137.
- FAO. (1996). Food for all poor. *World Food summit, FAO Rome*, Pp. 64.
- Hong, N. T. T. (2003). Evaluation of Sweet potato leaves as a protein source for growing pigs in Central Vietnam. *MSc Thesis, Department of Animal Nutrition and Management, SLU Uppsala, Sweden*.
- Longe, O.G. (1986). Energy Content of some tropical starch crop in Nigeria.*J. of Agriculture*, 21: 134-136.
- Olojo, E.A.A., Olurin, K.B., Mbaka, G. and Olumemino, A.D.(2005). Histopathology of the gill and Liver tissues of the African catfish *Clarias gariepinus* exposed to lead. *African Journal Biotechnology*, 4: 117 – 122.
- Olsson, J., Quevedo, M., Colson, C. and Svanback, R. (2007). Gut length plasticity in perch: into the bowels of resource polymorphisms. *Botanical Journal of the Linnean Society*, 90: 517-523.
- Sadekarpawar, S. and Parikh, P., (2013).Gonadosomatic and Hepatosomatic indices of freshwater fish world.*Journal of Zoology*, vol. 8, no. 1, pp. 110-118.
- Shim K.F., Landesman L. and T.J. Lam, (1989). Effect of dietary protein on growth, ovarian development and fecundityin the dwarf gourami *Colisalalia* (Hamilton). *J.Aquat. Trop.*, 4:111-123

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Comparative Study of the Effects Of Cooking Duration On Yield And Quality Of Oil Extracted From *Synodontis membranacea* and *Clarias anguillaris*

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Abstract

Fish belonging to the family Mochokidae and Clariidae have high fat content and this can be taken advantage of for fish oil production. Extraction of fish oil in this study was done by wet rendering and Folch method. The result of this study showed that the highest percent oil recovery from *Synodontis membranacea* was in wet rendering method at 40 minutes boiling time of the process (WRM₄₀) while in *Clarias anguillaris* it was in the wet rendering method at 20 minutes boiling time of the process (WRM₂₀). The peroxide values (PV) of the oil extracted by wet rendering method at 20 and 40 minutes cooking duration from the flesh and visceral of *Synodontis membranacea* and *Clarias anguillaris* were within the FAO/WHO food standards for fish oils except the solvent extracted. The acid value (AV), free fatty acid (FFA) of the flesh oil and visceral oil extracted by wet rendering method at 20 and 40 minutes cooking duration and solvent were within FAO/WHO food standards for fish oils. The two time processes of the wet rendering method yielded a high quality crude oil which has potential to be shelved.

Keywords: Cooking duration, Wet rendering method, Fish Oil, Quality, *Synodontis membranacea*, *Clarias anguillaris*

Introduction

Fish oil is an industrial product of great nutritional value due to its content of long chain omega-3 polyunsaturated fatty acids (PUFA), such as docosahexaenoic acid (DHA), docosapentaenoic acid (DPA) and eicosapentaenoic acid (EPA), which are currently highly valued for their prophylactic and therapeutic properties in nutritional and health fields (Bonilla-Méndez and Hoyos-Concha, 2018). Fish oil which is a by-product of fishmeal used for animal feed is now being recognized as the primary source of these fatty acids (Valenzuela *et al.*, 2012). Several studies have been developed around the extraction and quality analysis of oil obtained from different fish species, as well as by-products of their processing, in which different techniques are used, such as supercritical fluids, wet pressing, extraction using solvents, and fish silage employing enzymes present in fish or from other sources (Adeoti and Hawboldt, 2014).

The extraction of fish oil by wet pressing is the most commonly used method for production on an industrial scale, and is basically carried out in four stages: fish cooking, pressing, decantation and centrifugation (FAO, 1986). With the accrued health benefits of oils from fishes of marine origin there is also need to research into oils from fishes of freshwater origin but the extraction of fish oil from freshwater fishes industrially in Nigeria is uncommon. Hence the need to extract oil from two fish species of freshwater origin and to ascertain the quality of the oil extracted locally using one of the conventional methods of fish oil extraction.

The focus of this research was to extract oil from *Synodontis membranacea* and *Clarias anguillaris* at varied cooking time of the wet rendering method and determine the percentage oil yield and evaluate the quality of the oil.

Materials and Method

Fish samples

Synodontis membranacea and *Clarias anguillaris* used for this research work were purchased from fisher folks at Kainji Lake Dam and Abdulsalam Fish Farm in Kainji, and identified at the Fish Biology Section of the National Institute for Freshwater Fisheries Research, New- Bussa, Niger State.

Fish oil extraction process

Fish oil was extracted from the two fish species by the wet rendering method (WRM) at two time intervals; 20 minutes (WRM₂₀) and 40 minutes (WRM₄₀) respectively and solvent extraction (Folch *et al.*, 1957) with slight modification according to Cequier-Sanchez *et al.* (2008).

Determination of oil recovered

The fish oil recovered was determined using standard method as described by Gopakumar and Nair (1996).

$$\text{Percentage fish oil recovered} = \frac{\text{Weight of oil extracted (g)}}{\text{Weight of raw material used (g)}} \times 100$$

Determination of quality status of the fish oil

The crude fish oil were analyzed for their quality parameters which includes; Peroxide value AOAC (1997), acid value ISO 660 (1996) and free fatty acids AOCS (1998).

Statistical analysis

SPSS, version 15.0, software was used. The data are Mean $\pm$ standard deviation of 3 determinations. Data were statistically analyzed by One Way ANOVA and Duncan multiple range test of significance was used to separate the means.

Results

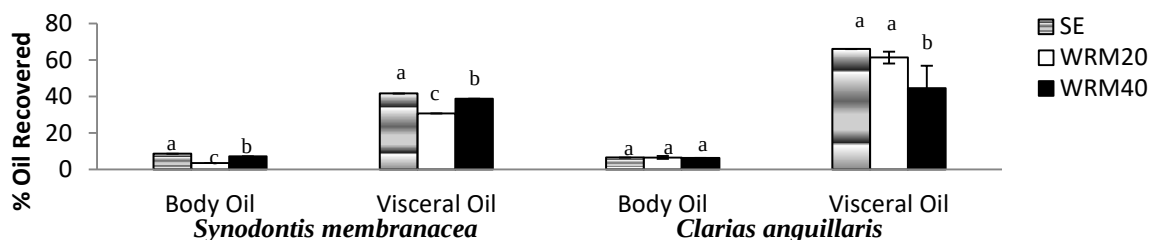


Figure 1: Percentage oil recovered from *Synodontis membranacea* and *Clarias anguillaris*

Note: SE- Solvent Extraction, WRM20- Wet Rendering Method at 20 minutes boiling time of the process, WRM40- Wet Rendering Method at 40 minutes boiling time of the process

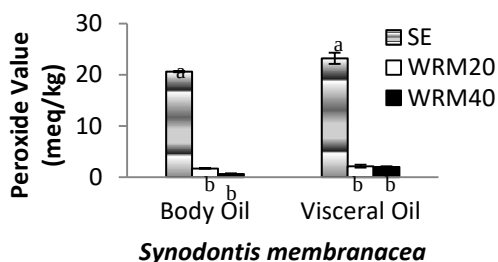


Figure 2: Peroxide values of oil from the flesh and viscera of *Synodontis membranacea*

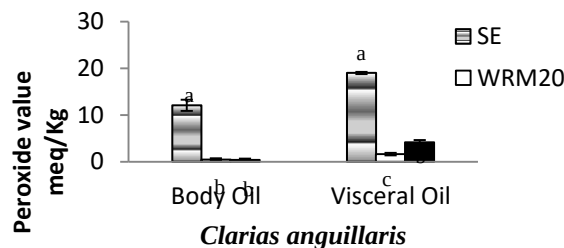


Figure 3: Peroxide Value of oil from the flesh and viscera of *Clarias anguillaris*

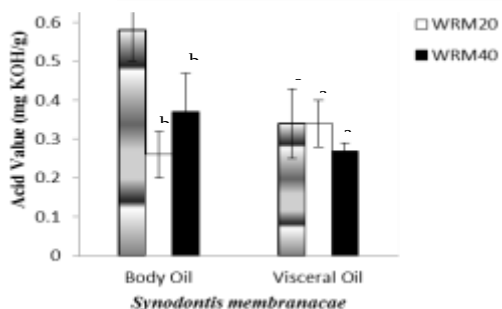


Figure 4: Acid value of oil from the flesh and viscera of *Synodontis membranacea*

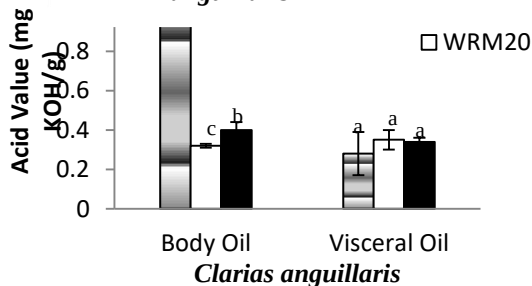


Figure 5: Acid Value of oil from the flesh and viscera of *Clarias anguillaris*

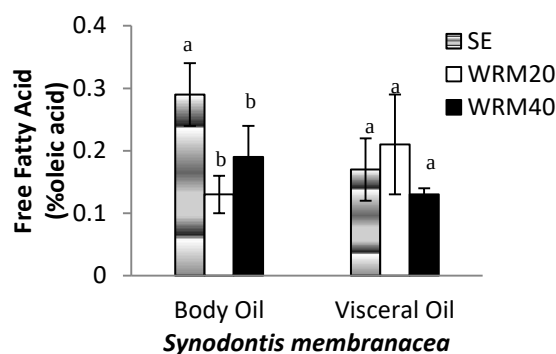


Figure 6: Free Fatty Acid Value of oil from the flesh and viscera of *Synodontis membranacea*

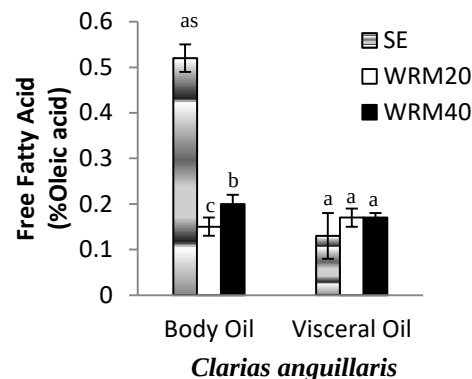


Figure 7: Free Fatty Acid Value of oil from the flesh and viscera of *Clarias anguillaris*

Discussion

Fish oil is usually derived from tissues and by-products of fatty fishes (Simat *et al.*, 2019). Fish oil was recovered from the flesh and visceral of *Synodontis membranacea* and *Clarias anguillaris* by wet rendering method at 20 minutes boiling time of the process (WRM₂₀), wet rendering method at 40 minutes boiling time of the process (WRM₄₀) and solvent method. The percentage oil recovered from the flesh and viscera of *Synodontis membranacea* and *Clarias anguillaris* can be seen in Figure 1. There was significant difference ($P < 0.05$) in the percentage oil recovered from the extraction methods. In *Synodontis membranacea*, the highest oil percentage was recovered by solvent extraction while the WRM₂₀ had the least both from the flesh and viscera. The percentage oil recovered from the *Clarias anguillaris* extracted by wet rendering method at 20 minutes boiling time of the process (WRM₂₀), wet rendering method at 40 minutes boiling time of the process (WRM₄₀) from the flesh and WRM₂₀ from the viscera had no significant difference ($P > 0.05$) when compared to the solvent extracted oil while WRM₄₀ visceral oil recovered was significantly decreased ($P < 0.05$) compared to the solvent extraction.

Due to the high content of PUFAs, fish oils are highly susceptible to oxidative spoilage. Peroxide value measures the degree of oxidative rancidity of oil and the amount of oxidized substance formed during lipid oxidation (Bruce, 1999). The peroxide values (Figures 2 and 3) in crude fish oil resulting from the WRM treatments of *Synodontis membranacea* and *Clarias anguillaris* respectively were low when compared to the solvent extracted oil. The values obtained in the WRM treatments for both fishes were within the Joint FAO/WHO food standard of the CODEX committee's proposed draft standard for fish oils (2017) except for the solvent extracted crude fish oil. Standard peroxide value according to CODEX Alimentarius commission (2017) and International Fish Oil Standards in (2011) is ≤ 5 meq/kg. High peroxide value indicates the oil has being oxidized due to several factors such as exposure to oxygen, high temperature, light and chemicals while low peroxide value may occur as a result of new peroxide formation rate which is smaller than the rate of degradation into other compounds.

The acid value (AV) measures the content of free fatty acids formed upon the hydrolytic degradation of lipid molecules, thus contributing to the reduction of the shelf life of the oil (Warner, 2008). The AV of oil from *Synodontis membranacea* and *Clarias anguillaris* are in Figures 4 and 5 respectively. The acid values of crude fish oil resulting from the solvent extraction and WRM treatments of *Synodontis membranacea* and *Clarias anguillaris* respectively are within the Joint FAO/WHO food standard of the CODEX Alimentarius commission (2017) and International Fish Oil Standards in 2011.

Free fatty acids (FFA) indicate the occurrence of hydrolytic rancidity due to cleavage of double bonds during frying (Paul and Mittal, 1997) that causes fatty acid esters to be freed from the glycerides as parent molecule (Hamilton and Rossell, 1986). FFA in fish oil is affected by extraction process parameters such as temperature, oxygen exposure and chemicals. The free fatty acid of the oil from *Synodontis membranacea* (Figure 6) and *Clarias anguillaris* (Figure 7) are within the International Fish Oil Standards (IFO, 2011).

Conclusion

The wet rendering method can be used for the extraction of quality oil from freshwater fishes flesh and visceral. The oil recovered from *Synodontis membranacea* increased with the increase in boiling time process of the WRM while the variation in the boiling process time had no effect on the percentage oil recovered from the flesh of *Clarias anguillaris*. The quality status of oils obtained by the wet rendering method treatments from *Synodontis membranacea* and *Clarias anguillaris* were within the acceptable limits of FAO/WHO food standard.

References

- Adeoti, I. A., & Hawboldt, K. (2014). A review of lipid extraction from fish processing by-product for use as a biofuel. *Biomass and Bioenergy*, 63, 330-340.
- AOCS (1998). Free fatty acids in: Official methods and recommended practices of the American oil chemists society. Vol. 5a. 5th ed. Champaign (US): AOCS Press.
- AOCS., 1997. Official Methods and Recommended Practices of the American Oil Chemists' Society. Official Method cd 8-53 Peroxide Value, cd18-90 p-ansidine Value, cg 3-91 *Recommended Practices for Assessing Oil Quality and Stability*. AOCS Press, Urbana, US.
- Bonilla-Méndez, J. R., Hoyos-Concha, J. L. (2018). Methods of extraction, refining and concentration of fish oil as a source of omega-3 fatty acids. *Corpoica Cienc Tecnol Agropecuaria*, Mosquera (Colombia), 19(3):645-668
- Bruce German J. (1999). Food Processing and Lipid Oxidation. *Advanced Experimental Medical Biology*, 8th edition, 23-50.
- Cequier-Sanchez E, Rodriguez C, Ravelo AG, Zarate R (2008). Dichloromethane as a solvent for lipid extraction and assessment of lipid classes and fatty acids from samples of different natures. *Journal of Agricultural Food Chemistry* 56:4297–4303.
- Codex (2017). Standard for fish oils CXS 329-(2017). *Report of the Twenty Forth Session of the CODEX Committee on Fats and Oils*. Joint FAO/WHO Food Standards Programme Codex Alimentarius Commission.
- Folch J, Lees M, Sloane G.H (1957). A simple method for the isolation and purification of total lipids from animal tissues. *Journal of Biological Chemistry*. 226(1):497-509.
- Gopakumar, K. and M. Nair, (1996). Fatty acid composition of eight species of Indian marine fish. *Journal of Science, Food and Agriculture*. 23: 493.
- IFOS (International Fish Oils Standard), 2011. Fish Oil Purity Standards. Retrieved form: [http:// www.omegavia.com/best-fish-oil-supplement-3](http://www.omegavia.com/best-fish-oil-supplement-3).
- ISO 660 (1996) Method of Sampling and Test for Oils and Fats? Determination of acid value and acidity. *I.S.I Handbook of Food Analysis (Part XIII)- 1984 page 67 IUPAC 2.201(1979)/I.S (Part I)- 1964*
- Šimat, V., Vlahović, J., Soldo, B., Skroza, D., Ljubenkova, I., & Generalić Mekinić, I. (2019). Production and Refinement of Omega-3 Rich Oils from Processing By-Products of Farmed Fish Species. *Foods (Basel, Switzerland)*, 8(4), 125.
- Valenzuela, A., Sanhueza, J., & De la Barra, F. (2012). El aceite de pescado: ayer un desecho industrial, hoy un producto de alto valor nutricional. *Revista Chilena de Nutrición*, 39(2), 201-209

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Assessment of the Proximate Composition and Fatty Acids in the Flesh of *Egeria radiata* (Larmack, 1804) Sold at Watt Market, Calabar, Cross River State

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Abstract

Egeria radiata is a fresh water clam inhabiting the lower reaches of some large West African River. Despite its popularity as a cheap source of animal protein in Nigeria, studies on its proximate and fatty acids are limited. This study was conducted to assess the nutritional qualities of *E. radiata* sold at watt market, Calabar, Cross River state. The clams was collected in plastic container and filled with freshly oxygenated water. Samples were collected at 7:00 am in the morning when the temperature was cool and taken to the biochemistry laboratory, University of Calabar for proximate composition, amino and fatty acids analysis. The samples were taken thrice, which was later analysed into three sampling regimes. Results of this study showed that there was a significant difference ($P < 0.05$) in all the proximate and fatty acids indices among the three sampling regimes. The results showed that *E. radiata* is rich in fatty acids (Stearic acid, oleic and alpha linolenic acid). Furthermore, fatty acids (Stearic acid, oleic and alpha linolenic acid) in *E. radiata* are important constituents of human nutrition. Therefore the balanced and healthy diet is a prerequisite for good health. The present study clearly indicates that the *E. radiata* are an important part of a balanced diet and contribute to a good nutritional status.

Keywords: Proximate composition, Fatty acids, *Egeria radiata*, Seafood

Introduction

Increase in global population has resulted to increase in per capita consumption of aquatic food including shellfishes (Ekpang and Oscar, 2018). According to Samya and Mohamed (2006), shellfishes have long been included as an important part of the diet of human populations especially in coastal areas. Due to the nutritional benefits of shellfishes, the current dietary guidelines have recommended increased consumption of seafood (Simopoulos, 2003).

Egeria radiata also known as Nkop by the Efiks belong to the Class Bivalvia (Etim and Brey 1994). Their existence extends from the Gulf of Guinea, Congo, Ghana, Cameroon to Nigeria where they are found widespread in the Cross River Basin all year round. *E. radiata* are commonly found in river waters with the following characteristics, water temperature (31°C), pH (5.1), free carbondioxide (5.7 mg L⁻¹), total alkalinity (35.0 mg L⁻¹) and salinity (0.051%) (Archibong *et al.*, 2014).

Over one billion people especially those living around the riverine areas, rely on *E. radiata* and other edible seafood as their primary source of protein and essential nutrients and there are reports of their health benefit as they contain vitamins and minerals in their correct proportions capable of replenishing the immune-compromised individuals. (Archibong *et al.*, 2014). Despite the aforementioned food value of *E. radiata*, little is known of its fatty acids composition for which knowledge in them could attract attention of nutritionists, government policy in sustainable exploitation as well as consumer's preference.

Materials and Methods

Collection of samples

The specimens of *E. radiata* were purchased from watt market, Calabar, Cross River state. The clams was collected in plastic container and filled with freshly oxygenated water. Samples were collected at 7:00 am in the morning when the temperature was cool and taken to the biochemistry laboratory for proximate composition and fatty acids analysis. The sample was taken thrice.

Sample preparation

The samples for analysis were separated into shell and soft tissues; the soft tissue was used for the analysis.

Proximate composition, amino and fatty acid analysis

The Proximate analysis of the *Egeria radiata* was performed according to AOAC (2000). The crude protein, moisture content, ether extract, ash, crude fiber, carbohydrates, fatty acid were analyzed respectively.

Statistical Analysis

Analysis of variance (ANOVA) was used to compare means of the proximate composition and fatty acid data. Further Duncan multiple test was carried out where there was significant difference at $P < 0.05$.

Results

Proximate composition of *Egeria radiata*

The results of the proximate composition of *E. radiata* bought from traders at Watt market, Calabar, Cross River state are presented in Table 1. The mean crude protein contents ranged between 40.39% and 46.68% with 3rd sampling regime having the highest value. Mean lipid contents ranged between 2.30% and 4.56% with 3rd sampling regime having the highest value. Mean moisture ranged between 12.97% and 14.50% with 2nd sampling regime having the highest value. Mean ash content ranged between 6.22% and 8.54% with 3rd sampling regime having the highest value. Mean carbohydrate content ranged between 41.35% and 45.35% with 3rd sampling regime having the highest value. Results of this study showed that there was a significant difference ($P < 0.05$) in all the proximate indices among the three sampling regimes.

Fatty acid composition of *Egeria radiata*

The profile of fatty acids bought from traders at Watt market, Calabar, Cross River state are presented in Table 2. Totally, about 7 different fatty acids were found in *E. radiata*, they are three saturated fatty acids (SFA), one monounsaturated fatty acid (MUFA) and three polyunsaturated fatty acids (PUFA). The highest percentage of SFA content was found in stearic acid (42.58%) from the 2nd sampling regime while margaric acid from 2nd sampling regime recorded the lowest value of 10.32% respectively. The percentages of MUFA for the 1st, 2nd and 3rd sampling regimes were 17.23%, 16.66% and 18.65% respectively. The highest percentages of PUFA content was found in α lenolenic acid (16.60%) from 3rd sampling regime while stearidonic acid from second sampling regime recorded the lowest value (3.26%) respectively. Results of this study showed that there was a significant difference ($P < 0.05$) in all the fatty acid indices.

Table 1: Proximate composition *E. radiata*

Parameters	MEAN 1 ST SAMPLING	MEAN 2 ND SAMPLING	MEAN 3 RD SAMPLING	F-value	P-value	Comment, $\alpha=0.05$
Crude Protein	40.39±0.40 ^a	42.58±0.90 ^b	46.68±1.39 ^c	31.51	0.00	Significant
Lipid	2.34±0.19 ^a	2.30±0.19 ^a	4.56±0.40 ^b	64.85	0.00	Significant
Moisture	12.97±0.03 ^a	14.50±0.36 ^c	13.40±0.51 ^b	14.45	0.01	Significant
Ash	6.22±0.14 ^a	7.69±0.34 ^b	8.54±0.18 ^c	74.79	0.00	Significant
Carbohydrate	41.35±0.26 ^a	43.69±0.50 ^b	45.35±0.35 ^c	83.12	0.00	Significant

*Values are mean±SD of three replicates; Means separated with different superscript are significantly different

Table 2: Fatty acid Composiion of *Egeria radiata*

Parameters	MEAN 1 ST SAMPLING	MEAN 2 ND SAMPLING	MEAN 3 RD SAMPLING	F-value	P-value	Comment, $\alpha=0.05$
S F A						
Palmitic acid	13.93±0.07 ^a	14.20±0.36 ^b	15.59±0.29 ^c	32.07	0.00	Significant
Margaric acid	10.37±0.05 ^a	10.32±0.19 ^a	11.46±0.32 ^b	26.27	0.00	Significant
Stearic acid	41.94±0.20 ^a	42.58±1.00 ^b	40.48±0.37 ^c	8.73	0.02	Significant
MUFA						
Oleic acid	17.23±0.07 ^a	16.66±0.31 ^b	18.65±0.39 ^c	37.67	0.00	Significant
PUFA						
Linolenic acid	5.11±0.03 ^a	6.78±0.17 ^a	5.66±0.30 ^a	53.74	0.00	Significant
α linolenic acid	14.47±0.17 ^a	15.27±0.27 ^b	16.60±0.39 ^c	41.62	0.00	Significant
Stearidonic acid	4.06±0.06 ^b	3.26±0.26 ^a	5.84±0.17 ^c	158.92	0.00	Significant

Discussion

In the present study, 7 different fatty acids were identified, 3 saturated fatty acids (SFA), 1 monounsaturated fatty acids (MUFA) and 3 polyunsaturated fatty acids (PUFA).

Studies have found evidence that α -linolenic acid is related to lower risk of cardiovascular disease (Srilatha, 2013). Dietary α -linolenic acid has been assessed for its role in cardiovascular health (Srilatha, 2013).

Shanmugam *et al.*, (2007) recorded 36 individual fatty acids that were identified. Among them, the saturated fatty acids were the dominant fatty acids (35.28%) and most of which were 18:0 (15.68%) and 14:0 (7.15%). The MUFA are often referred to as “good” fats because studies have shown that they help in reducing blood cholesterol levels and protect against heart disease (Srilatha, 2013).

Abundance of 16:1 and 18:1 triacylglycerols of *Tapes decussatus* and *T. philippinarum* has been reported by Beninger and Stephan (1985). Zhukova and Svetashev (1986) observed a sum of monounsaturated acids ranged from 19.7% to 25.4% in five species of bivalves. Polyunsaturated fatty acids are energy source and also function in the body as components of membranes, modulators of gene expression and precursors for eicosanoids (self-healing agent).

Conclusion

The results of the present study provide information about the proximate and fatty acid composition and also suggest the consumption of this bivalve, *E. radiata*. It is rich in fatty acids (Stearic acid, oleic and alpha linolenic acid). Further, the presence of fatty acids (Stearic acid, oleic and alpha linolenic acid) in *E. radiata* adds more value through the possibility. Therefore the balanced and healthy diet is a prerequisite for good health. The present study clearly indicates that the *E. radiata* are an important part of a balanced diet and contribute to a good nutritional status.

References

- Annaian, S., Chendur, P., and Subramaniam, S. (2007). Some valuable fatty acids exposed from wedge clam *Donax cuneatus* (Linnaeus). *African Journal of Biochemistry Research* Vol. 1 (2), pp. 014-018.
- AOAC, Association of Official Analytical Chemists (2000). Official methods of Analysis. 17th Edition, Washington D.C. pp 234.
- Archibong, A.N., O.E. Ofem, A.A. Akwari, S.U. Ukwani, A.E. Eno and F.N. Beshel (2014). Extract of edible seafood-*Egeria radiata* (Clam) boosts blood parameters in rats. *British Journal of Applied Science and Technology* 4:1684-1692.
- Beninger PG, Stephan G (1985) Seasonal variations in the fatty acids of the triacylglycerols and phospholipids of two populations of adult clam (*Tapes decussatus* L. and *T. philippinarum*) reared in a common habitat. *Comp Biochem Physiol Part B: Biochem Mol Biol* 81: 591-601.
- Ekpang and Oscar (2018). Proximate Composition and Mineral Contents of Edible Part of Four Species of Shellfishes from the Calabar River, Nigeria. *Annual Research & Review in Biology*. 26(1): 1-10.

- Etim, L., & Brey, T. (1994). Growth, productivity and significance for fishery of the bivalve *Egeria radiata* (*Donacidae*) in cross River, Nigeria. *Archive of Fishery and Marine Research*, 42:63-72.
- Samya, H.M., & Mohamed, S.Y (2006). Proximate evaluation of some economical seafood as a human diet and as an alternative prospective valuable of fish meal. *Journal of Fisheries and Aquatic Science*. 11(1):12-27.
- Simopoulos AP (2003). Importance of the ratio of omega-6/omega-3 essential fatty acids: Evolutionary aspects. *World Review on Nutritional Diet*. 92:1-22.
- Srilatha, G., Chamundeeswari, K., Ramamoorthy, K., Sankar, G., and Varadharajan D. (2013). Proximate, Amino Acid, Fatty Acid and Mineral Analysis of Clam, *Meretrix casta* (Chemnitz) from Cuddalore and Parangipettai Coast, South East Coast of India. *Journal of Marine Biology Oceanography*. 2: 19-37.
- Zhukova NV, Svetashev VI (1986) Nonmethylene- interrupted dienoic fatty acids in molluscs from the sea of Japan. *Com Biochem Physiol B* 83: 643- 646.

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Haematological and Biochemical composition of *Clarias gariepinus* (Burchell, 1882) Juvenile fed Diet Containing Sweet Potato (*Ipomoea batatas*) Leaf Meal

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Abstract

The haematological and serum protein of the African Catfish (*Clarias gariepinus*) juvenile of mean average weight (5.56 ± 0.01 g) and mean length 6.70 ± 0.26 cm fed with varying dietary inclusions level of sweet potato (*Ipomoea batatas*) leaf meal as protein supplements for 10 weeks were determined. Five iso-nitrogenous (35% crude protein). Sweet potato leaf meal was incorporated in the diet at 0 (control), 2.5, 5, 7.5 and 10%. Blood parameters such as haemoglobin (Hb), packed cell volume (PCV), red blood cell count (RBC), mean cell volume (MCV), mean cell haemoglobin (MCH), mean cell haemoglobin concentration (MCHC), Neutrophil (Neu), Lymphocytes (Lym), Monocytes (Mon), Alanine Aminotransferase (ALT), Creatinine (CRT), Albumin (ALB) were estimated. Statistical analysis revealed that these parameters were marginally different ($P > 0.05$) among all the groups including control, except white blood cells count (WBC), Total protein (PRO), Aspartate Aminotransferase (AST) and Alkaline Phosphate (ALP) respectively, containing diets 2.5% sweet potato leaf meal were significantly lower ($P < 0.05$) compared with the control. However the values recorded for the parameters in all the groups were within haematological values recommended for cultured African Catfish. This suggests that the leaf powder of Sweet potato (*Ipomoea batatas*) leaf meal is safe and non-toxic at 10% inclusion level and had no negative impact on the health status of the African Catfish.

Keywords: sweet potato leaf meal, *Clarias gariepinus*, haematological parameters

Introduction

In Nigeria, greater proportion of fish supply is from the capture fisheries, which do not meet the demand of the ever-increasing population (Maduet *et al.*, 2003). The need to explore aquaculture for massive fish production is imperative (Lovell, 1992). One of the most important components of aquaculture is fish feeding (Aydin *et al.*, 2011). Feed alone has been estimated to account for 40-70% of the cost of aquaculture operations (Pathmasethy, 1983; Olvera-Nova, 1996). Thus, the importance of efficiency of utilization of the fish feed cannot be over emphasized. Non-Conventional Feed Resources (NCFRs) are feeds that are not usually common in the market and are not the traditional ingredients for commercial fish feed production (Devendra, 1988; Maduet *et al.*, 2003). NCFRs are credited for being non-competitive in terms of human consumption and cheaper to purchase (Devendra, 1988). They are mostly by-products from agriculture, farm made feeds and processing industries. They may include all types of feed stuffs from animal (silk worm, maggot, termites, earth worm, snails, tadpoles etc.), plant waste (cotton seed meal, soy bean meal, maize bran, rice bran, palm kernel cake, groundnut cake and brewers waste) from plants (duckweed, Cajanus and Chaya) waste from animals such as animal dung, offal, visceral, feather, fish silage, bone and blood (Devendra, 1988; Omitoyin and Faturoti, 2000). All these can be recycled to improve on fish feed production if economically justified and technologically possible (Devendra, 1988; Omitoyin and Faturoti, 2000).

Sweet potato grows best at an average temperature of 24°C (75°F) with abundant sunshine and warm nights. Annual rainfall of 750-1000mm is considered most suitable with a minimum of 500mm in the growing season (Austin, 1988). It is cultivated in over 100 nations and ranks fifth among the most important food crops in the tropical areas (An, 2004). According to Hong (2003), sweet potato is a major tropical crop with a short and fast growth cycle. Blood cells responses are important indicators of changes in the internal or external environment of fish and these changes depend on fish species, age, sexual maturity and diseases (Golovina, 1996; Lusova, 1997). Haematological evaluation is important in assessing the quality, health status, monitoring stress responses and suitability of feed ingredients in farm animals (Maxwell *et al.* 1990; Animashahun *et al.*, 2006). Animashahun *et al.*, 2006 also reported that the nutrient levels in the blood and body fluids may not be valid indicator of nutrient function at cellular level but are considered to be proximate measures of long-term nutritional status. The aim of this study was to evaluate the haematological and biochemical condition of *Clarias gariepinus* fed with sweet potato leaf meal.

Materials and Methods

Experimental Site

The study was conducted at the fish nutrition experiment units of the Department of Biotechnology, Badore research center NIOMR, Lagos.

Processing of Sweet potato Leaf meal

Sweet potato plant was cultivated at IITA, Ibadan Oyo State for the purpose of this research. The leaf was plucked from the stem and was thoroughly washed with water to remove dirt, drained properly and later shade-dried at room temperature at the fish nutrition Laboratory for three weeks (21 days), the leaves were blended into fine powder and sieved using 1.18mm laboratory sieve to remove the residues. The fine particles were used in combination with other ingredients to produce pelleted feed and analysed for proximate composition according to (AOAC, 2000). The parameters of importance were: crude protein, crude fat, crude fibre, moisture content and total ash.

Procuring and Processing of other Feed Ingredients

The other feed ingredients used in the diet were fish meal, cassava meal, soy bean meal (industrial), fish premix, vitamin C and anti mould. They were sourced from departmental Feed mill in the institute.

Experimental Diets

Five diets containing varying levels of sweet potato leaf meal at 0 % (Diet 1), 2.5% (Diet 2), 5% (Diet 3), 7.5% (Diet 4) and 10% (Diets 5) were formulated following Pearson Square Method. The diets were isonitrogenous (each containing 35% crude protein). The appropriate quantities of ingredients in each diet were weighed and mixed thoroughly using electric feed mixer (Kenwood). Each diet was thereafter mixed with water to make dough. The mixed dough was subjected to pelleting using Hand manure pelleting and 2mm disk diameter. The pelleted feeds were sundried and broken into smaller sizes appropriate to the fish and size stored until the commencement of the feeding trial. Table 1 shows the gross compositions of experimental diets.

Table1. Gross composition of experimental Diets

Ingredients	Sweet Potato Leaves meal inclusion %				
	0	2.5	5	7.5	10
Fish meal	18.00	15.50	13	1.50	8.00
Sweet potato	0.00	2.50	5.00	7.50	10.00
SBM	26.00	27.50	30.00	33.00	35.00
GNC	20.00	20.50	22.00	23.00	25.00
Corn	32.30	30.30	26.30	22.30	18.30
Vitamin premix	0.50	0.50	0.50	0.50	0.50
Vegetable oil	2.50	2.50	2.50	2.50	2.50
Vitamin C	0.50	0.50	0.50	0.50	0.50
Anti mould	0.20	0.20	0.20	0.20	0.20
Total	100	100	100	100	100

Key: sweet potato Leaf Meal, SBM Soya Bean Meal

Experimental Fish Management

Experimental fish in each plastic tank were fed at 5% body weight for 10 weeks of feeding period. The fish were fed two times daily. The tanks were cleaned, and uneaten feeds together with faecal residues were siphoned out before feeding. Water levels were maintained

Blood collection and Analysis

At the end of the feeding trial, blood samples were collected from three fish randomly selected from each replicate of the groups. The blood samples were collected at 1.5 milliliters (ml) from the caudal peduncle of the fish as described by (Joshi, 2000). Hemoglobin was estimated by cyano-methemoglobin, white blood cells (WBC) were counted by Neubauer's improved hemocytometre using Hyem's, and Turk's solution as diluting fluid method as described in (Stoskopf, 1993). Red blood cell (RBC) and packed cell volume (PCV) were estimated as described in (Blaxhall and Daisley, 1973). Mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentrate (MCHC) and mean cell volume (MCV) were calculated using standard formulae as described by (Dacie and Lewis, 1991) and (Joshi, 2000).

Biochemical analysis

Serum creatinine was determined by the Human Diagnostic Laboratories Kit using Jaffe method of Deproteinisation. Creatinine forms in alkaline solution an orange –red coloured complex with picric acid. The serum is first deproteinised with trichloroacetic acid (1.2 mol. /L) and centrifuged at high speed for 5-10minutes.

The supernatant was mixed with 1.0ml of mixture of picric acid and sodium hydroxide (1.6mol/l) and incubated for exactly 20min at room temperature. The absorbance of the complex which was proportional to the creatinine concentration in the sample was measured against the reagent blank at 546nm.

Calculation

$$\text{Calculation} = \frac{\text{Absorbance of sample}}{\text{Absorbance of standard}} \times \text{concentration of the standard}$$

$$= \frac{A_{\text{sample}}}{A_{\text{standard}}} \times 2.0 \text{ (mg/dl)}$$

Determination of Total protein (Biuret methods)

Principle

Protein molecules are composed of aminoacids arranged in long chains called peptide chains. The links which join the amino acids together are known as peptide bonds. In the Biuret reaction, the cupric ions in the reagent join with the peptide bonds of the protein molecules in an alkaline solution to form a blue-violet coloured complex.

BIURET METHOD

1. For each sample, pipette into test tubes 1.0ml of biuret reagent (test) and 1.0ml of blank biuret reagent (reagent blank)
2. Add 0.02ml (20µl) of each sample to the test and 20µl water to the blank
3. A standard test tube is also set up for each batch and contains 20 µl of standard protein 1.0ml of biuret reagent.
4. Mix and allow standing at room temperature for 30minutes or 10 mins at 37°C.
5. Zero the instrument with the reagent blank solution.
6. Measure the absorbance of the test and the standard at 546nm wavelength.
- 7.

Determination of serum Albumin

Albumin is the most abundant serum protein representing 55-65% of the total protein. It is synthesized in the liver and has a half-life of 2 to 3 weeks.

The measurement of serum albumin is based on its quantitative binding to the indicator 3, 3', 5,5'-tetrabromo-m cresol sulphonephthalein (bromocresol green, BCG). The albumin-BCG-complex absorbs maximally at 578nm, the absorbance being directly proportional to the concentration of albumin in the sample. 100µl of serum sample was dispensed into 3.0ml of BCG reagent (produced by Randox cat, No. AB 362.). Mix and incubate for 5min at 20-25°C. Measure the absorbance of the sample (A sample) and at the standard (A standard) against the reagent blank at 578nm wavelength using spectrophotometer.

Calculation

$$\text{Albumin Concentration (g/dl)} = \frac{A_{\text{sample}}}{A_{\text{standard}}} \times \text{concentration of standard (4.68)}$$

Statistical Analysis

The data on the haematological and Biochemical composition obtained were subjected to analysis of variance (ANOVA) and the treatment means were separated using Duncan Multiple Range Test (Steel and Torrie, 1980). The analysis was carried out using SPSS version 20.0.

Results and Discussion

The results of haematological and biochemical analysis were as presented on Table 2. The hematological indices of blood are useful in monitoring feed toxicity especially with feed constituents that affect the formation of blood. However, all the haematological parameters measured in this study were within the recommended physiological ranges reported for *Clarias gariepinus*. The Haemoglobin (Hb), packed cell volume (PCV), and red blood Cell (RBC) were low in fish fed experimental diets 7.5 and 10% sweet potato leaf meal inclusion. However, a decrease in the hematological parameters of fishes at significant level ($P > 0.05$) was due to the level of inclusion in the diets.

This observation was in support of the works of (Osuigweet *et al.*, 2005, Sotolu and Faturoti, 2011) who reported the reduction in value of packed cell volume (PCV), Haemoglobin (Hb) and Red Blood Cell (RBC) due to the toxic substance in diet of fish.

There was an increase in White Blood Cell (WBC) and Mean Cell Volume (MCV) across the dietary treatment of the experimental fish fed with varying sweet potato leaf meal, this increment in whole blood cells and Mean Cell Volume (MCV) in the circulatory system contributed to better survival rate of the experimental fish. The Mean Cell Haemoglobin (MCH) and lymphocyte the values were decreases across all the dietary treatments and were significantly different ($p > 0.05$). However, these values were higher than the values obtained by (Falaye *et al.*, 2018) who fed *Clarias gariepinus* with Moringa leaf meal. The Mean Cell Haemoglobin concentration (MCHC), the values were decreased as the level of inclusion increases. These values were not in line with finding by (Falaye *et al.*, 2018) who fed *Clarias gariepinus* with Moringa leaf meal. There were an increase in Neutrophils and monocyte count of all the dietary treatments and statistically different ($p < 0.05$). Increase in the total neutrophil count has been reported to be a sign of bacterial infection or as a result of stress.

For the serum in Table 2. There were significant increase ($p < 0.05$) in the activities of serum enzymes (Aspartate aminotransferase AST, Alanine aminotransferase ALT and Alkaline phosphatase, ALP) as the level of Sweet potato leaf meal increased considerably from 2.5% in the diet. Elevated AST, ALT and ALP activities in fish fed 10% sweet potato leaf meal diet and above are suggestive of hepatic cellular damage leading to their leakage into circulation (Molander *et al.*, 1957; Mousa *et al.*, 2008). Certain serum chemistry could be used to identify tissue damage (Pattin and Kulkarni, 1993). Aspartate aminotransferase (AST), Alanine aminotransferase (ALT) and Alkaline phosphatase (ALP) are normally found within the cells of the liver, heart, gills, kidneys, muscles and organs (Shalaby, 2009) but their increase in the plasma indicates tissue injury or organ dysfunction (Wells *et al.*, 1986). Changes in enzymes profiles are important toxicity indices (bio-markers) and have been used to assess the biochemical and physiological health of vital organs (tissues) in fishes (Van der Oost *et al.*, 2000; Gabriel and George, 2005).

Table 2: Haematological and Biochemical Analysis of Sweet Potato Leaf Meal

Parameters	Sweet potato leaf meal inclusion levels %				
	0	2.5	5	7.5	10
Hb (g/dl)	12.60±2.10 ^a	9.60±0.60 ^b	11.80±0.41 ^a	8.40±1.80 ^{bc}	7.80±0.91 ^c
PCV (%)	36.00±0.16 ^a	29.00±0.21 ^c	34.00±0.04 ^b	27.00±0.08 ^{cd}	26.00±0.01 ^d
RBC (x10 ⁶ /l)	4.00±0.37 ^a	3.20±0.12 ^b	3.60±0.35 ^b	2.90±0.35 ^c	2.90±0.25 ^c
WBC (mm ³)	8960±1.80 ^a	6144±0.99 ^e	8192±0.89 ^b	7040±1.90 ^d	7552±1.80 ^a
MCV (fl)	90.00±0.01 ^b	90.63±0.06 ^b	94.44±0.86 ^a	93.10±0.19 ^a	89.66±0.66 ^a
MCH (pg)	31.50±0.04 ^b	30.00±0.14 ^c	32.77±0.14 ^a	27.93±0.20 ^d	26.89±0.44 ^e
MCHC (g/dl)	35.00±2.01 ^a	33.10±0.68 ^b	34.71±0.81 ^{ab}	30.00±0.67 ^c	30.00±0.17 ^c
Neu (%)	10.00±0.01 ^d	18.00±0.03 ^c	19.00±0.04 ^{bc}	20.00±0.06 ^b	22.00±0.09 ^a
Lym (%)	88.00±0.61 ^a	79.00±0.38 ^b	80.00±0.11 ^b	77.00±.88 ^c	75.00±0.91 ^c
Mon (%)	2.00±0.41 ^b	3.00±0.02 ^a	1.00±0.01 ^c	3.00±0.07 ^a	2.00±0.06 ^b
Biochemical					
PRO (g/l)	22.06±0.14 ^{bc}	15.88±0.23 ^e	19.16±0.71 ^c	28.87±0.01 ^b	32.63±0.08 ^a
AST (U/l)	38.16±0.08 ^b	28.01±0.13 ^e	36.72±0.01 ^d	41.75±0.03 ^b	46.22±0.36 ^a
ALT (U/l)	14.62±0.11 ^b	10.24±0.39 ^c	12.00±0.39 ^c	10.40±0.10 ^d	16.32±0.34 ^a
ALP (U/l)	67.00±0.03 ^e	82.00±0.07 ^c	77.00±0.08 ^d	84.00±0.06 ^b	88.00±0.07 ^a
UREA (mg/dl)	2.36±0.32 ^b	3.06±0.11 ^a	2.94±0.13 ^b	2.75±0.17 ^b	3.05±0.12 ^a
CRT (mg/dl)	19.60±0.61 ^c	20.25±0.67 ^c	28.25±0.25 ^b	34.08±0.10 ^a	15.83±0.21 ^d
ALB (g/dl)	1.60±0.01 ^c	2.20±0.63	1.90±0.06 ^{bc}	2.20±0.01 ^b	2.60±0.01 ^a

Means with the same superscript along the row indicate no significant ($P > 0.05$) difference

Key: Haemoglobin (Hb), Pack Cell Volume (PCV), Red Blood cell (RBC), white blood cell (WBC), Mean Cell Volume (MCV), Mean Cell Haemoglobin (MCH), Mean Cell Haemoglobin concentration (MCHC), Neutrophil (Neu), Lymphocytes (Lym), Monocytes (Mon), Total protein (PRO), Aspartate Aminotransferase (AST), Alanine Aminotransferase (ALT), Alkaline Phosphate (ALP), Creatinine (CRT), Albumin (ALB)

Conclusion and Recommendation

In conclusion, the results obtained from this study showed that sweet potato leaf meal could be included in fish feed up to 10% level in *Clarias gariepinus* diets without any negative effects on the blood and serum enzyme. The use of sweet potato leaf meal as protein Supplements in fish feed is recommended to strengthen the immunopathological system in fish.

References

- Animashahun R.A., Omoikhoje, S.O. and Bamgbose, A.M. (2006). Haematological and biochemical indices of weaner rabbits fed concentrates and Syndrellanodiflora forage supplement. Proceedings of 11th Annual conference of AnimalScience association of Nigeria. Institute of Agricultural Research and Training, Ibadan, Nigeria, pp: 29-32
- An, L.V. (2004). Sweet potato leaves for growing pigs: Biomass yield, digestion and nutritive value. Ph.D. thesis, Swedish University of Agriculture Sciences, Pp 49.
- A.O.A.C (2000). *Official Methods Of Analysis Analysis* 24TH edition, Association of Official Analytical Chemist., Washinton D.C.
- Austin, D.F. (1988). The taxonomy, evolution and genetic diversity of sweet potatoes and related wild species In: P. Gregory (ed.). Exploration, Maintenance and Utilization of Sweet potato Genetic Resources CIP, Lima, Peru. Pp 27-60.
- Aydin, A., Karlo, M., Mert, S., Kamil, B., Burcu, O. and Sebnem, H. (2011). Prevalence and Antibiotic resistance of foodborne *Staphylococcus aureus* isolates in Turkey. *Foodborne Pathogens and disease*; 8, (1), 63-69.
- Blaxhall, P.C. and Daisley, K.W. (1973). Routine haematological methods for use with fish blood. *J Fish Biol.*, 5:771-781.
- Dacie, S.I.V, Lewis, S.M. (1991). Practical Hematology, 7th edition, Churchill Limited, London, 231.
- Devendra, C. (1988). General approaches to animal nutrition research and their relevance to fish production in the Asian region. In: S.S. Desilva (Ed), *Finfish Nutrition Research in Asia*. Asian Fisheries Society. Singapore. 7-24.
- Falaye, A., Eyiwumi, O.A. and Awhefeada, K. O. (2018). The Hematological parameters of Catfish (*Clarias gariepinus*) fed Fish Feeds with replaced Premix using Moringa Leaf Meal (MLM). *Madridge Journal of Aquaculture Research & Development*. 2(1): 2638-2210
- Faturoti EO (2000) Effects of supplementary feeding and organic manuring on the production of African catfish: *Clarias gariepinus* (Burchell 1822). *J West Africa Fish* 4: 187-195.
- Golovina, N.A. (1996). Morpho-functional characteristics of the blood of fish as object of aquaculture. PhD Thesis. Moscow: University of Moscow.
- Joshi, P.K., Bose, M and Haish, D. (2000). Changes in certain Hematological parameters in a silurid catfish *Clarias batrachus* (Linn) exposed to cadmium chloride. *Pollution Resources*, 21 (2): 129-131.
- Gabriel, U.U, George A.O.I, (2005). Plasma enzymes in *Clarias gariepinus* exposed to chronic levels of roundup (glyphosate). *Environ Ecol*, 23(2): 271-276.
- Hong, N. T. T. (2003). Evaluation of Sweet potato leaves as a protein source for growing pigs in Central Vietnam. M.S.c. Thesis, Department of Animal Nutrition and Management, SLU Uppsala, Sweden.
- Lovell, R.T. (1992). Nutrition and Feeding of Fish. Van Nostrand Reinhold New York., 43.
- Luskova, V. (1997). Annual cycles and normal values of hematological parameters in fishes. *Acta Scientiarum Naturalium Academiae Scientiarum Bohemicae Brno* 31: 66-70.
- Madu, C.T., Sogbesan, O.A., Ibiyo, L.M.O. (2003). Some non-conventional fish feed resources in Nigeria. In: A. Eyo (Ed.) Proceeding of the Joint Fisheries Society of Nigeria /National Institute for Freshwater Fisheries Research/FAO-National Special Programmed for Food Security, National Workshop in Aquaculture held at the National Institute for Freshwater Fisheries Research. 73-83.
- Maxwell MH, W Robertson, S Spener and CC MacIorquodale, (1990). Comparison of haematological parameters in restricted and ad libitum fed domestic fowls. *British PoulSci*, 31: 407-413.
- Molander, D.W., Sheppard, E., Payne, M.A. (1957) Serum transaminase in liver disease. *J Am Med Assoc*. 163: 1461-1465.
- Mousa, M.A., El-Ashram, A.M. and Hamed, M. (2008). Effects of Neem leaf extract on freshwater fishes and zooplankton community. 8th International Symposium on Tilapia in Aquaculture. The Central Laboratory for Aquaculture Research, Cairo, Egypt. October 12 - 14.
- Olvera-Nova, M.A. (1996). The dietary protein requirement of *Cichlasoma synspillum* fry. *Aquaculture Research*. 167-173.
- Omitoyin, B.O., Faturoti, E.O. (2000). Effect of raw and parboiled chicken offal in the diet of *Clarias gariepinus*. *Aqua byte*. 1: 20-25.
- Osuigwe, D. I., Obiekezie, A. I. and Onuoha, G. C. (2005). Some haematological changes in hybrid catfish (*Heterobranchus longifilis* x *Clarias gariepinus*) fed different dietary levels of raw and boiled jackbean (*Canavalia ensiformis*) seed meal. *African Journal of Biotechnology* 4 (9): 1017-1021.

- Pathmasethy, S.A. (1983). Review of feed, their processing and feeding techniques in Malaysian aquaculture system. In: Chan, H.H., Ang, K.J., Ibrahim, H.M. and Ambark, M.A. (eds.), Proceedings of the International Conference on Developmental and Management of Tropical Living Aquatic Resources, 126-131.
- Patti, M.Kulkarni, R.S.(1993). Ovarian and hepatic biochemical response to Sumach (a crude form of HCG) in fish, *Notopterus notopterus* pallas, under pesticide treatment. *Geobios*, 20:255-259.
- Shalaby, A.M.E, (2009). The opposing effects of ascorbic acid (Vitamin C) on ochratoxin toxicity in Nile tilapia (*Oreochromis niloticus*). <http://www.ag.arizona.edu/ista/ista6web/pdf/209.pdf>. Retrieved: 05-04-09.
- Sotolu, A. O. and Faturoti, E. O. (2011). Digestibility and Nutritional Values of Differently Processed *Leucaena leucocephala* (Lam De Wit) Seed Meals in the Diet of African Catfish (*Clarias gariepinus*). *Middle-East Journal of Scientific Research* 3 (4): 190–199.
- S.P.S.S. V.23.0.(2020). Statistical Package for Social Package Sciences <http://www.winwrap.com>.
- Steel, G.D, and Torrie, J.H. (1980). *Principles and Procedure of Statistics*. A Biometrical Approach. Second edition. 633p.
- Stoskopf, M. K. (1992). *Fish Medicine*. W. B. Saunders Company, Harcourt Braces Jovanovich Inc. Philadelphia, London. 125pp.
- Van der Oost R, Satumalay A.I, Vermeulen, N.P.E, (2000). Validation of inland water pollution assessment using biomarker response in caged carp (*Cyprinus carpio*). *Mar Environ Res*, 50:431-432.
- Wells, R.M, McIntyre, R.H. Morgan, A.K. Davie, P.S.(1986). Physiological stress response in big game fish after exposure: Observation on plasma chemistry and blood factors. *Comp Biochem Physiol*, 84:565–571.

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Haematological and Biochemical Composition of African catfish (*Clarias gariepinus*) Fingerlings fed with Yam (*Dioscorea spp*) Leaf Meal

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Abstract

This study evaluated the effect of replacing fishmeal with varying inclusion levels of yam leaf meal on the haematological and biochemical indices of *Clarias gariepinus* fingerlings after a feeding trial of 8 weeks. A total of two hundred *C. gariepinus* fingerlings of 2.17 ± 0.02 g mean body weight were randomly allotted into plastic tanks at 20 fish per tank for the five treatments (trial feeds) in duplicates and fed twice daily at 3% body weight. Five experimental diets were formulated with varying levels of yam leaf meal at 2.5%, 5%, 7.5% and 10% with a control diet containing 100% fishmeal. All the diets were iso-nitrogenous (35% crude protein level). Haematological data obtained were as follows: Hb 6.5-11.2g/dl; PCV 20-33%, RBC $2.2-3.5 \times 10^6$ /dL; WBC 5760-9856/mm³; MCV 88.46-94.28(fl); MCH 28.7-32(pg); MCHC 31.43-33.94(g/dl); Neu 27-38(%); Lym 59.0-70.0(%); Mon 2-5(%). Results for biochemical indices were as follows: PRO 26.31-38.88(g/l); AST 48.86-69.23(U/l); ALT 20.83-34(U/l); ALP 160-180(U/l); Urea 3.05-3.91(mg/dl); CRT 33.99-53.34(mg/dl); ALB 3.7-4.4(g/dl). The results indicated that yam leaf meal can be included in the diets of *C. gariepinus* without any adverse effects on its blood parameters.

Key words: Yam leaf meal, *Clarias gariepinus*, haematological and biochemical indices.

Introduction

Fish culture easily appears to be the next viable option for meeting the rising global demand for fish consumption. To achieve this objective, there is an urgent need to cut down on production cost viz a viz feed cost. This has prompted a lots of nutrition studies to exploit the potentials of animal and plant sources as alternative ingredients in aquafeed. Animal sources are expensive and not so readily available/sustainable. Plant sources on the other hand, have the advantage of availability and are less expensive. They contain good amounts of protein, different amino acids and fatty acids which are lacking in animal protein (Singh, 2019). Leaf meals are one of the cheapest sources of proteins that can be used to reduce costs; despite the fact that much research efforts have concentrated on grains and tubers.

Yams are cultivated mainly for the consumption of their [starchy](#) tubers in tropical and subtropical regions like Africa, Asia, etc. The leaves are ignorantly under-rated and are usually thrown away/discarded, supposedly with no known competitive alternative uses. Emerging research however has shown that yam leaves are even more nutritious than carrots, spinach, celery and cucumbers when it comes to vitamin B, vitamins A and C, riboflavin, fiber, zinc, protein, antioxidants, calcium and iron. They enhance immune function, boost metabolism, lower blood sugar, improve eyesight, and act as an anti-inflammatory (Woks of Life, 2020). Yam leaves and roots have also been used in traditional Chinese medicine to help reduce symptoms associated with asthma, nausea, and inflammation. In the Philippines, yam leaves are blended and used with baby food as a source of increased nutrients. Other cultures also use the roots and leaves as a food source and as a pain reliever (Yam Leaves Information and Facts, 2021). The potential for use of yam leaf in fish feed is therefore worth studying as there is paucity of information on its utilization. The aim of this study is to investigate the effects of different inclusion levels of yam leaf meal on the haematological and biochemical indices of *C. gariepinus* juveniles.

Materials and Methods

Collection and Processing of Yam Leaf Meal

Fresh leaves of the yam plant (*Dioscorea spp.*) were obtained from IITA, Ibadan, Nigeria. The leaves were plucked from the stem and shade-dried to a constant weight. After drying, they were milled into fine powder using a laboratory milling machine, sieved and stored in an air-tight container for analysis.

Experimental Diets

Five diets containing varying levels of yam leaf meal at 0 % as control (Diet 1), 2.5% (Diet 2), 5% (Diet 3), 7.5 % (Diet 4) and 10% (Diets 5) were formulated following Pearson Square Method. The diets were isonitrogenous (each containing 35% crude protein). The ingredients were weighed, mixed thoroughly, then pelletized using a manual feed pelletizer of 2mm disc diameter. The pelleted feeds were sun-dried and stored until the commencement of the feeding trial. Table 1 shows the gross compositions of the experimental diets.

Table1. Gross composition of experimental Diets

Ingredients	Yam Leaves meal inclusion %				
	0	2.5	5	7.5	10
Fish meal	18.00	15.50	13	1.50	8.00
Sweet potato	0.00	2.50	5.00	7.50	10.00
SBM	26.00	27.50	30.00	33.00	35.00
GNC	20.00	20.50	22.00	23.00	25.00
Corn	32.30	30.30	26.30	22.30	18.30
Vitamin premix	0.50	0.50	0.50	0.50	0.50
Vegetable oil	2.50	2.50	2.50	2.50	2.50
Vitamin C	0.50	0.50	0.50	0.50	0.50
Anti mould	0.20	0.20	0.20	0.20	0.20
Total	100	100	100	100	100

Key: Yam Leaf Meal, SBM Soya Bean Meal

Experimental setup

The experimental fish were distributed randomly into ten plastic tanks (0.53 x 0.37 x 0.25m dimensions) with 20 fingerlings in each tank. The five experimental diets were randomly allocated to the experimental tanks, in a completely randomized design (CRD) with two replicates per treatment and were fed twice daily at 3% of their body weight for 8 weeks.

Haematological Assessment

At the end of the experiment, samples of fish from all the experimental treatments were subjected to haematological analysis. 1.5 millilitres (ml) of blood were collected from the caudal peduncle as described by Joshi *et al.* (2000).

Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA) and the treatment means were separated using Duncan Multiple Range Test (Steel and Torrie, 1980). The analysis was carried out using SPSS version 20.0 (SPSS, 2013).

Results and Discussion

Table 2 shows the haematological and biochemical parameters of *Clarias gariepinus* fingerlings fed varying inclusion levels of yam leaf meal. The values were well within the recommended physiological ranges reported for *Clarias gariepinus* (Eyiunmi *et al.*, 2018; Dinye and Olumuji 2014). The results showed significant differences in the levels of the blood parameters across all the dietary treatments. Fish fed with the 10% YLM diet had significantly higher values of Hb, PCV, RBC, WBC, MCV, MCH and MCHC than fish fed with the other diets; similar to the results recorded by Ukonze *et al.* (2021) and Olasukanmi *et al.* (2021). PCV values obtained in this study were lower than that reported by Agbabiaka *et al.* (2013). Duwa *et al.* (2014) reported a strong influence of diet on haematological traits, using PCV and Hb as strong indicators of nutritional status of animals. Hb values observed in this study were lower than those obtained by Adesina (2017). Haemoglobin concentrations reflect the oxygen supply of an organism. High value of RBC recorded in this study was also reported by Akintayo *et al.* (2008) to be an indication of high oxygen absorption and transportation capacity of the cells of the fish under study.

The increase in WBC of *C. gariepinus* in this study might indicate that they had high immunity or resistance to disease. The high values observed for MCH in this study compared favourably with that of Olasunkanmi (2011), indicating a good volume of haemoglobin which results in effective oxygen transportation in the bloodstream for healthy wellbeing of the fish (Diyaware *et al.*, 2013). Significant differences were observed in serum biochemical indices of the fish fed with the test diets. Slight variations were observed in the levels of serum protein and enzymes.

The observed decrease in the total protein and albumin content of fish at different inclusion levels could be due to the level of anti-nutrients present in the diets; and possibly, the high fibre content as well.

Conclusion and Recommendation

From the findings above, inclusion of yam leaf meal in the diet of *C. gariepinus* fingerlings is recommended. This will help to take advantage of its numerous nutritional benefits for fish health as well as humans; and at the same time prevent its wanton wastage.

Table 2: Haematological and Biochemical Parameters of *C. gariepinus* Fingerlings fed Experimental Diets

Parameters	Yam leaf meal inclusion levels %				
	0	2.5	5	7.5	10
Hb (g/dl)	9.00±2.10 ^b	6.60±1.02 ^d	6.50±0.01 ^d	7.80±0.30 ^c	11.20±0.02 ^a
PCV (%)	28.00±1.31 ^b	21.00±0.21 ^d	20.00±0.02 ^d	23.00±0.40 ^c	33.00±0.44 ^a
RBC (x10⁶/L)	3.10±0.93 ^a	2.30±0.22 ^{bc}	2.20±0.14 ^c	2.60±1.00 ^b	3.50±0.34 ^a
WBC (mm³)	6912±0.81 ^b	6016±0.10 ^d	5760±1.12 ^e	6784±2.30 ^c	9856±2.41 ^a
MCV (fL)	90.32±0.11 ^c	91.30±0.01 ^b	90.90±0.19 ^{bc}	88.46±1.94 ^d	94.28±1.11 ^a
MCH (pg)	29.03±0.81 ^c	28.70±0.10 ^d	29.55±0.19 ^{bc}	30.00±1.41 ^b	32.00±1.22 ^a
MCHC (g/dl)	32.14±1.33 ^b	31.43±0.15 ^c	32.50±0.11 ^b	33.91±1.81 ^a	33.94±1.19 ^a
Neu (%)	32.00±0.14 ^b	28.00±0.19 ^{cd}	38.00±0.01 ^a	27.00±1.42 ^d	30.00±1.31 ^c
Lym (%)	66.00±1.40 ^b	68.00±0.20 ^b	59.00±0.14 ^d	70.00±1.83 ^a	65.00±1.56 ^c
Mon (%)	2.00±1.44	4.00±0.33 ^b	3.00±0.02 ^c	3.00±0.01 ^c	5.00±0.17 ^a
Biochemical					
PRO (g/l)	26.31±1.24 ^c	35.01±1.30 ^b	38.88±1.33 ^a	29.02±1.33 ^d	31.45±1.12 ^c
AST (U/l)	60.26±0.29 ^c	56.60±1.10 ^d	67.89±1.00 ^b	69.23±0.95 ^a	48.86±1.13 ^e
ALT (U/l)	20.83±1.15 ^e	34.00±0.29 ^a	25±1.12 ^d	29.17±1.09 ^c	31.11±0.81 ^b
ALP(U/l)	188±0.02 ^a	179±0.04 ^c	166±1.03 ^a	180±0.88 ^b	178±1.11 ^{cd}
UREA (mg/dl)	3.81±0.18 ^a	3.05±0.45 ^b	3.91±0.03 ^a	3.07±0.04 ^b	3.42±0.06 ^b
CRT (mg/dl)	43.48±1.49 ^b	40.72±0.71 ^c	34.20±0.21 ^d	33.99±0.12 ^d	53.34±0.61 ^a
ALB (g/dl)	4.40±0.55 ^a	3.8±0.81 ^b	4.2±0.85 ^a	4.00±0.77 ^a	3.7±0.31 ^b

Means with the same superscript along the row indicate no significant ($P>0.05$) difference

Key: Haemoglobin (Hb), Pack Cell Volume (PCV), Red Blood cell (RBC), white blood cell (WBC), Mean Cell Volume (MCV), Mean Cell Haemoglobin (MCH), Mean Cell Haemoglobin concentration (MCHC), Neutrophil (Neu), Lymphocytes (Lym), Monocytes (Mon), Total protein (PRO) Aspartate Aminotransferase (AST), Alanine Aminotransferase (ALT), Alkaline Phosphate (ALP), Creatinine (CRT), Albumin (ALB).

References

- Adesina, S.A. (2017). Haematological and Serum Biochemical Profiles of *Clarias gariepinus* Juveniles Fed Diets Containing Different Inclusion Levels of Mechanically Extracted Sunflower (*Helianthus annuus*) Seed Meal. *Applied Tropical Agriculture* 22 (2): 24-35.
- Agbabiaka, L.A., F.N. Madubuike and B.U. Ekenyem. (2013). Haematology and Serum Characteristics of African Catfish (*Clarias gariepinus* Burchell) Fed Graded Levels of Tigernut-based Diet. *American Journal of Experimental Agriculture*, 3 (4): 988-995.
- Akintayo, I.A., Obasa, S.O., Alegebeleye, W.O. and Bamgbose, A. M. (2008). Evaluation of toasted sunflower (*Helianthus annuus*) seed meal in the diets of African catfish (*Clarias gariepinus*) fingerlings. *Livestock Research for Rural Development*, 18: 11-22.
- Dienye H.E. and Olumuji O.K. (2014). Growth performance and haematological responses of African mud catfish *Clarias gariepinus* fed dietary levels of *Moringa oleifera* leaf meal. *Net J. Agric Sci* 2(2):79-88,
- Diyaware, M.Y., A.B. Haruna and K.A. Abubakar. (2013). Some haematological parameters of intergeneric hybrid of African catfish (*Clarias anguillaris* × *Heterobranchius bidorsalis*) juveniles and their pure lines in north-eastern Nigeria. *Journal of Fisheries and Aquatic Science*, 8 (1): 33-42.
- Duwa, H., Saleh, B. and Igwebuike, J. U. (2014). The Replacement of Fish Meal with Maggot Meal on the Performance, Carcass Characteristic, Haematological And Serum Biochemical Indices Of Growing Rabbits *G.J.B.B.*, 3 (2): 215-220.
- Eyiunmi, F.A, Augustine O, and Ovie W.K. (2018). The Hematological parameters of Catfish (*Clarias gariepinus*) fed Fish Feeds with replaced Premix using Moringa Leaf Meal (MLM). *Madridge J Aquac Res Dev.*2(1): 35-39.
- Joshi, P.K., Bose, M and Haish, D. (2000). Changes in certain Hematological parameters in a siluroid catfish *Clarias batrachus* (Linn) exposed to cadmium chloride. *Pollution Resources*, 21 (2): 129-131.
- Olasunkanmi J.B., Babalola T.O., Jimoh J.O. and Omisani O.V. (2021). Performance of *Clarias gariepinus* fed plantain peel meal as replacement for maize. *IOP Conf. Ser.: Earth Environ. Sci.* 655: 012-016.

- Olasunkanmi, J.B. (2011). Nutrient utilisation and growth performance of *Clarias gariepinus* fed differently processed Mucuna utilis meals as a replacement for soybean-based diet. PhD. Thesis, University of Ibadan, Ibadan, Nigeria. 209pp.
- S.P.S.S 20.0 (2013). *Statistical Package for Social Sciences* <http://www.winwrap.com>.
- Singh R. K., (2019). Use Of Plant Leaves as Fish Meal. www.pashudhanpraharee.com RNI No.: JHAHIN/2012/46453. ISSN: 2319-6971 (Print)).
- Steel, G.D, and Torrie, J.H (1980). *Principles and Procedure of Statistics. A Biometrical Approach*. Second edition. 633p.
- The Woks of Life, (2020). <https://thewoksoflife.com> © 2013-2021.
- Ukonze, J.A. , E.N. Odo, N.I. Ossai, N.I. Dimelu and H.O. Agu. (2021). Production, proximate and hematological implications of substituting black bean meal in the diet fed catfish. J. Fish. Aquat. Sci., 16: 1-11.
- Yam Leaves Information and Facts. <https://specialtyproduce.com> © 1996-2021

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Growth and Survival of Catfish (*Clarias gariepinus* x *Heterobranchus bidorsalis*) Hybrid Fingerlings Fed Varying Level of Cotton (*Gossypium spp*) Seed Meal

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Abstract

This research was carried out on growth and survival of hybrid (*Clarias gariepinus* x *Heterobranchus bidorsalis*) fed varying level of cotton (*Gossypium spp*) seed meal. The growth performance and feed utilization were analysed in comparison with the conventional commercial fish feed. Five experimental rations formulated were cotton-seed (*Gossypium Spp*) meal replaced GNCat graded levels of 0%, 15%, 30%, 45% and 60% and were fed to hybrid (*C. gariepinus*) for 56 days, the experiment was conducted in 15 outdoor concrete tanks in the department of Fisheries and Aquaculture, Usmanu Danfodiyo University, Sokoto, Nigeria. Data for each parameter were subjected to Analysis of variance (ANOVA) and the means for various experimental diets were compared for significant differences at 0.05% level of inclusion. The results showed that fish fed with D1 which has 0% gave the best Body Weight Gain (82.54g), Specific Growth Rate (0.122), Feed Conversion Ratio (2.41), while diet DV gave the least Weight Gain (46.19g), Specific Growth Rate (-0.20), and has highest Feed Conversion Ratio (3.12). The results were significantly different ($p < 0.05$) for both growth and feed utilization parameters. Cotton-seed meal can be used as a replacement for GNC at 15% level of inclusion. The results established significant reduction in production cost while optimal production is achieved.

Key words: Survival, Growth performance, Hybrid, cotton Seed Meal

Introduction

The demand of fish is increasing throughout the world due to the recognition of its nutritional value (Tingman *et al.*, 2010). In addition, the rise of food price and rapid human world population growth increase the demand of fish consumption (FAO, 2010; FAO 2012). For this reason, there are varieties of farming fish species which get a special consideration to increase the world fish production. Fish plays significant role in the diets of people. Fish feeds account for about 70% of aquaculture operations, and most fish farmers in Nigeria do not make use of standard fish feed due to high cost of fish feed ingredients and the overall cost of production (Adekunle *et al.*, 2012; Orire and Sadiku, 2014). The cost of fish diet is driven by the high cost of fishmeal, an important ingredient in aquaculture. However, there is need to research for cheaper and readily available unconventional sources of protein either from plant or animal to meet the nutritional requirement of targeted fish species. Animal and non-animal proteins derived from legume, oil seeds or cereal gluten are now introduced in fish diets (Médale *et al.*, 2013).

In this context, the formulation of fish feed using a cheap, locally available and highly nutritious terrestrial resource such as Cotton seeds is needed. The protein content is highly variable as it depends on the amount of de-hulling and the efficiency of oil extraction. The range of protein content is from 30% DM for non-de-hulled cottonseed meal up to 50% DM for fully de-hulled meals (Feedipedia, 2016). One of the major factors militating against fish farming in Nigeria has been lack of adequate feed that are formulated to meet the nutrient requirements of culturable fish species (Olarinde, 2005; Olaniyi, 2009). As such fishes do not attain market size at the right age (Gabriel *et al.*, 2007). Nigerian fish farmers hardly use good quality fish feed pellets (Jamu and Ayinla, 2003; Omitoyin, 2007) due to high cost of fish feed ingredients particularly fishmeal. Omitoyin (2007) reported that a lot of fish farmers in Nigeria depend on imported quality fish feeds which are usually expensive.

Fishmeal is the most used protein ingredient for feed production due to its high protein content, balanced amino acid profile and high digestibility. It is also a good source of essential fatty acids, digestible energy, macro and trace minerals and vitamins, and generally acts as feed attractant for most finfish species (Cho and Kim, 2011). Hence, aquaculture utilizes a lot of fishmeal to remain one of the fastest growing animal food-producing sectors. Aquaculture sector alone consumed the equivalent of about 23.8 mmt of fish (live weight equivalent) or 87% of non-

food fish in the form of feed inputs in 2006 (Tacon and Metian, 2009). Soya beans meal, groundnut cake and some other plant protein source have also become too expensive (Ojewola and Udom, 2005). Utilization of such commercially formulated feeds increases the cost of production thereby reducing the profit margin of fish farmers. Fishmeal is known to contain complete Essential Amino Acids (EAAs) profile that is needed to meet the protein requirement of most fish species. Since fish meal is expensive as a feed ingredient, the use of non-conventional feedstuffs has been reported with good growth and better cost benefit values (Sogbesan, and Ugwumba, 2008). The aim of this research is to assess the growth and nutrient utilization of Catfish (*Clarias gariepinus* x *Heterobranchus longifilis*) hybrid fingerlings fed vary level of cotton seed meal at different substitution level.

Materials and Methods

Experimental Site

This research was conducted at the outdoor hatchery, Faculty of Agriculture, Department of Fisheries and Aquaculture, Usmanu Danfodiyo Sokoto. Sokoto is located in the extreme North West of Nigeria; near the confluence of Sokoto River and River Rima. The State is within the longitude 11° 30'-130° 50'E and latitude 4°-6° 40'N (Wikipedia 2018). Sokoto state is located in the dry Sahel surrounded by sandy savannah and isolated hills with an annual average temperature of 28.3°C (82.9°) there are two seasons; the Dry and Wet season. Dry season begins in from October to April and extends to May/June in some parts. Wet season starts in May and ends September to October. Harmatan is experienced between November and February. Heat is more severe around March and April.

Source of Cotton-seed Meal

Cotton-seed meal cake was purchase from Kano, TafawaBalewa Road, Nasarawa Local Government of Kano State, Nigeria. The seed meal cake was grinded using pestle and mortar, and sieved using 1.18mm laboratory sieve to remove the residues. The fine particles were used in combination with other ingredients to produce pelleted feed.

Procuring of other Feed Ingredients

The other feed ingredients that formed the ration include: groundnut cake (GNC), fish meal, maize, blood meal, bone meal, vitamin and mineral premix, palm oil and salt. They were sourced within Sokoto metropolis.

Proximate Analysis

Proximate compositions of the feed ingredient were carried out at the chemical and physical Laboratory of the Faculty of Agriculture, Usmanu Danfodiyo University Sokoto. Percentage protein, fat, moisture, ash, fiber and nitrogen free extract (NFE) were determined for each ingredient following the method of AOAC (2000).

Experimental Diets

Five diets containing varying levels of cotton seed meal (CSM) at 0%, 15%, 30%, 45% and 60%. The diets were formulated following peason square method. The diet contains 45% crude protein. The appropriate quantities of the ingredient in each diet were weighed and mix thoroughly using electric feed mixer (Kenwood). Each diet was further mix with warm water to make dough. The mix dough was subjected to an electric power feed pelletizer (50/kg capacity/hour) of 4mm in diameter size. The palliated feeds were sundried and broken into smaller size appropriately acceptable to fish at the beginning of the experiment and stored before the commencement of the feeding trial

Table1. Gross composition of experimental Diets

INGREDIENTS	(0%)	(15%)	(30%)	(45%)	(60%)
Maize	9.41	4.01	11.60	2.80	3.82
GNC	13.86	10.65	6.70	3.17	0.00
Fish meal	5.54	5.68	5.36	5.08	5.21
Cotton seed cake		3.55	6.70	9.52	13.04
Blood meal	2.77	2.84	2.68	2.54	2.60
Bone meal	0.56	0.56	0.56	0.56	0.56
Palm oil	0.75	0.75	0.75	0.75.0	0.75
Salt	0.63	0.63	0.63	0.63	0.63
Vitamin premix	12.5	12.5	12.5g	12.5g	12.50
Mineral premix	0.13	0.13	0.13	0.13	0.13
Total	100	100	100	100	100

Crude protein	45	45	45	45	45
Metabolizable energy	3494.36	3469.91	3379.33	3298.30	3435.39
k/cal					
Calculation/C.p.	44.3247	43.1204	39.3175	35.9162	35.3914

Fish Sources and Management

A total of 300 *Clarias gariepinus* × *Hetrobranchus longifilis*, hybrid fingerlings was obtained from National Institute for fresh water Fisheries New Bussa, Niger State. The fish were transported in twenty-five litters (25) half-filled plastic jerry can with water. In the hatchery they were acclimatized for one week in two nursery ponds of 750 litres capacity at the rate of 150 fish per pond, after which they were fed with 45% crude protein diets (control). They were then redistributed evenly and randomly to each pond. All fish were feed daily at 10.00 am and 5.00 pm at rate approximately 5% of their average body weight for 8 weeks of the feeding trial period. The ration was adjusted weekly base on the new weight gain in each pond. The ponds were clean and uneaten feeds together with faecal residues were siphoned out before feeding. The fish in each pond was weighed to ensure uniformity in size in each pond, and the five experimental diets were randomly allocated to the experimental ponds, in a completely randomized design (CRD) with three replicates. The water source for the experiment was University borehole, and Dissolved oxygen was maintained. After acclimatization the fish, each tank has twelve fish. At stocking, body weight of 25g of fishes per pond was maintained. Water level was maintained in each pond and was washed completely every week, and new water was impounded to each pond.

Experimental Set-up

The experimental set-up consists of fifteen outdoor concrete tanks of 404.4 liter capacity (0.87m,) the concrete tanks were cleared and cleaned. Each tank was assigned to each of five experimental diets containing different level of cotton-seed meal, pond 6,8,15 were the control which contain 0% cotton seed, pond 4,5,10 contain 15% cotton seed, pond 7,9,13 contain 30% cotton seed, pond 3,11,14 contain 45% cotton seed, pond 1,2,12 contain 60% of cotton seed. The water level was maintained at 0.68m throughout the experimental period and the waste water was replaced every four days.

Water Quality Analysis

Water quality parameters such as Temperature, Hydrogen ion concentration (pH) and Dissolve Oxygen (DO) were determined in all the tanks using standard methods described by APHA (1980). Water temperature was taken with thermometer in °C. The thermometer was lowered into water and retained for about 2-5 minutes and the value recorded. pH – this was determined by using rent EIL model 7055 pH meters. The pH meter was lowered into the water sample for about 3-5 minutes and recorded. Dissolved oxygen was determined using YSI model 57 oxygen meter calibrated parts per million (ppm).

Measurement of Weight Increment

The body weight was recorded on weekly basis by weighing all the fingerlings in each experimental unit on an electric top loading weighing balance. The average weekly weight gain in each tank was obtained by subtracting the average weight of fingerlings during the previous week from the average weight during the current week, until end of the experiment (9 weeks).

Data collection

During or at the end of experiment the following data were collected;

Survival rate (SR)

$$SR = \frac{\text{Initial number of fish stocked} - \text{mortality}}{\text{Initial number of fish}} \times 100 \text{Bagenal (1978)}$$

Mean weight gain (g) = Final mean weight (g) - Initial mean weight (g)

Percentage Weight Gain

$$PWG = \frac{\text{Final mean weight} - \text{initial mean weight}}{\text{Initial body weight}} \times 100 \quad \text{Webster and Chhorn (2001)}$$

Specific Growth Rate (SGR)

$$SGR = \frac{\ln W_2 - \ln W_1}{T_2 - T_1} \times 100 \quad \text{Stickney (1979)}$$

Where In = Natural logarithm

$W_2 - W_1$ = final and initial weight of fish (g) and

$T_2 - T_1$ = period in days

Feed Conversion Ratio (FCR)

$$FCR = \frac{\text{Feed fed (g)}}{\text{Weight gain (g)}} \quad \text{Hepher (1988)}$$

Feed Efficiency Ratio

$$FER = \frac{\text{Weight gain (g)}}{\text{Feed fed (g)}} \quad \text{Hepher (1988)}$$

Protein Efficiency Ratio (PER)

$$PER = \frac{\text{Weight Gain (g)}}{\text{Crude Protein Consumed}} \quad \text{Hepher (1988)}$$

Apparent Net Protein Utilization (AppNPU)

$$APPNPU = \frac{N_b - N_a}{N_i} \times 100 \quad \text{Chow } et al. (1985)$$

Where N_b = Body protein at end of the experiment

N_a = Body protein at the beginning

N_i = Amount of Nitrogen (protein ingested)

Statistical Analysis

The data on nutrient composition of cotton seed meal, growth performance and nutrient utilization obtained were subjected to analysis of variance (ANOVA) and the treatment means were separated using Duncan Multiple Range Test (Steel and Torrie, 1980). The analysis was carried out using SPSS version 20.0.

Results and Discussion

Cotton Seed Meal

The crude protein of cotton-seed meal in this study was 26.08 %. This value is higher than what was reported by Ashiru *et al.*, (2011)22.06%, Mujahidet *et al.*, (2000) of 17.74%. The variations in crude protein of cotton-seed have been attributed to the environmental condition in addition to varieties. The crude protein of cottonseed meal of Chinese source (international feed number. 5-01-619) obtained by grinding the residual press-cake after removal of most of the oil was 47% crude protein (Simon *et al.*, 2008). In this study, the crude protein was in the same range with that of (Ashiruet *et al.*, 2011). The importance of crude protein to *Clarias gariepinus* x *Heterobranchus* is for tissue building, body defence, growth, transportation of oxygen and reproduction. The crude protein of some non-conventional fish feed of plant source are: locust bean seed range from 22.88%-25.81% (Duniya, 2006).

Albizzia seed range from 38.04%-33.19% (Anwa, 2006). The crude protein of some nonconventional fish feed of animal source are: 63.0±4.5, 63.8±3.6, 46.3±3.2, 43.5±3.4, 45.9±2.5, 47.8±4.1 for earthworm meal, garden snail meal, Termite Meal, Un-skinned dried tadpole, un-skinned-boiled tadpole, skinned tadpole meal respectively (Sogbesan and Ugwumba, 2008). The result of proximate of the ingredient in this study shows the same result with Jibrin *et al.*, (2018) who use calabash seed cake. The crude fibre according to the proximate analysis of the *Gossypium* Spp. used in this study was 14.5 while Ashiruet *et al.*, (2011)17.01, Simon *et al.*, (2008) reported the crude fibre content of cottonseed meal of Chinese source as 12.5%. The crude fibre content of some non-conventional fish feed of plant origin were: locust bean seed, range from 2.04% and 1.13% (Duniya, 2006); Albizzia seed, range from 19.03%-11.63% (Anwa, 2006).

Certain feed stuff designated as non- conventional feed resources (NCFR'S) include mango seed, defatted, cocoa cake, sorghum and also include silk worms, grubs, housefly maggots, termites, earth worms, snail (Sogbesan and Ugwumba, 2008, Okonkwo and Oladipupo, 2010). They are non-competitive in terms of human consumptions and are cheap by-product or waste products and their use sometime enhance environmental sanitation. Fibre is used by *Clarias gariepinus* to aids digestion and prevents many diseases of digestion tract.

The Crude Ash content of cottonseed meal according to this study was 7.0 but from Ashiruet *et al.*, (2011)5.93%. Mujahidet *et al.*, (2000) the average crude ash content of cottonseed meal of different varieties was 4.27%. The Crude ash content contains minerals which are essential to the maintenance of life e.g., calcium, chlorine, iron, phosphorous, potassium, sodium, and sulphur. The standard lipid requirement of most fish's ranges from 8-10% (Adikwu, 1987). But the lipid in this study is 3.0 and Ashiruet *et al.*, (2011)reported 20.09%. The crude protein content and carbohydrate contents shows progressive decreases in values in the fish after the experiment compared to that at the beginning. The crude fibre, lipid, and ash content shows progressive increase in values in the fish after the experiment compared to the fish before the experiment.

Table 2: Proximate Composition (%) of Ingredient

Ingredient	Moisture	Ash	Oil/lipid	Crude fibre	Crude protein	NFE
Cotton seed cake	3.00	7.00	3.00	14.50	26.08	46.42
GNC	8.00	8.50	8.50	4.00	40.51	30.49
Blood meal (BM)	10.50	13.00	0.50	0.50	51.54	23.96
Fish meal (FM)	10.00	10.00	0.50	Trace	71.00	8.50
Maize (M.Z)	5.50	9.50	1.50	3.00	10.41	70.09

Fish Growth

According to this study, fish fed 0% had significantly higher body weight gain (82.54 ± 5.38) than those fed 15, 30, 45 and 60% cotton seed meal. This suggested greater protein utilization in fish fed 0% Cotton-seed meal in the diet of *Clarias gariepinus* x *Heterobranchus* fingerlings. This indicating the control has the highest weight gain follows by 15% cotton seed meal. This contradict with the finding by Ashiruet *et al.* (2011) whose used 20% cotton seed meal, the result showed adverse effect on the final body weight of *Clarias gariepinus* and similar trained was also observed for Specific Growth Rate and Feed Conversion Ratio. Simon *et al.*, (2008) obtained 91.29g for fish fed 15% inclusion level of cotton-seed meal of *Clarias gariepinus* juveniles' diets also recorded mean body weight gain of 67.18 and 48.13 for *Clarias* fed 45% and 60% inclusion level of cottonseed meal respectively.

Balogun *et al.* (2004) reported that, weight gain and standard-length increases are known to be the most essential parameters for measuring fish responses to experimental treatments and liable indicator of growth, using *Dionisregia*. Sanz *et al.*, (1994) evaluated the nutritive potential of sunflower meal protein as compared to soybean meal and fish meal protein in trout diets and they found that, sunflower meal protein could be replaced up to 40% of fish meal protein or soybean meal protein in the diet at the same replacing percentage in trout diets without any negative impact on body weight. Olvera-Novoa *et al.* (2002) showed the possibility to replace animal protein source in tilapia fry diets with sunflower seed meal up to 20% without significant effect in body weight of Nile tilapia fry while the highest replacing levels significantly decrease the body weight. In another study, El-Saidy and Gaber (2002) found that up to 50% dehulled sunflower meal protein could be used to replace fish meal as a protein source in the diet of Nile tilapia (*Oreochromis niloticus*) without significant effect on the Body Weight. But from the experiment carried out, this indicates that CSM could substitute groundnut cake at 15%. Because the weight gain of fish fed diet II (82.08 ± 18.36) which shows the difference of just 0.4 between the control diet I and diet II which is clear indication that CSM could substitute groundnut cake at 15% regardless the highest mean weight of fish fed diet I at 0% CSM (0% substitution of GNC). Similarly, percentage weight gain and specific growth rate were in the same trend on *C. gariepinus* fed water hyacinth and mucuna beans replacement for plant protein sources (Konyem *et al.*, 2005; Bekebile, 2005) and also the same result with (Jibrinet *et al.*, 2018), Mamman *et al.* (2013) and Alfa (2006) when fed *C. gariepinus* juveniles and *Oreochromis niloticus* Trewavas fingerling with calabash seed meal. The lower mean body weight recorded in fish fed diet containing 45%, 30% and 60% cotton seed meal may also be due to the high level of cotton seed meal substitution. However, the results revealed were significant ($p < 0.05$) difference in the weight gain of all the dietary treatments.

Nutrient Utilization

There was a decrease in weekly feed intake with increasing level of cotton seed meal. The same was reported by Jibrinet *et al.*, 2018. This may be a quality to the physical as well as chemical composition of the diets. Stickney (1979) reported that some chemicals and physical properties of diets such as texture, water stability and colour could affect their acceptability. The proportion of cotton seed meal in the diets could have been an indicator for decreasing feeding intake. The lower values of feed conversion ratio of (2.43 ± 0.04 to 3.12 ± 0.40) recorded in all the treatments suggested partial efficient utilization of the dies. Jibrinet *et al.* (2018) 4.23 ± 0.05 to 15.73 ± 3.44 how used calabash seed meal.

Stickney *et al.* (1979) reported that feed conversion ratio becomes lower as efficiency of utilization increases. However, the values recorded in the present study were not too far from Konyemeet *et al.*, (2005), Sotulo and Sule (2011) and Bekibele (2005) who reported the values of FCR of 3.75 and 2.66 when fed *C. gariepinus* with water hyacinths and mucuna bean as plant protein supplement. The protein efficiency ratio (PER) and Apparent Net Protein Utilization shows in table 3

Table 3: Growth performance and Nutrient Utilization of *C. gariepinus* fed Cotton Seed meal

Parameter	Diet/treatment				
	(0%)	(15%)	(30%)	(45%)	(60%)
Percentage survival rate	11.33±0.6 ^a	11.33±1.2 ^a	10.67±1.5 ^a	11.00±1.00 ^a	9.67±1.23 ^a
Specific growth rate	0.12±0.04	0.11±0.14	0.01±0.08	0.05±0.12	-0.20±0.10
Initial weight (g)	25.30	25.30	25.40	25.60	25.70
final weight (g)	95.61	97.90	82.40	89.90	63.70
Weight gain	82.50±5.40 ^b	82.0±18.40 ^b	67.6±9.60 ^b	74.40±14.60 ^b	46.20±7.20 ^a
Percentage weight gain (%)	325.80±21.70 ^b	325.03±74.00 ^b	264.76±36.55 ^{ab}	290.81±58.70 ^b	179.89±29.36 ^a
Feed conversion ratio	2.44±0.03 ^a	2.44±0.11 ^a	2.62±0.11 ^a	2.51±0.24 ^a	3.12±0.39 ^a
Feed efficiency ratio	0.41±0.01 ^b	0.41±0.03 ^b	0.38±0.02 ^b	0.40±0.04 ^b	0.323±0.040 ^a
Protein efficiency ratio	14.97±3.32 ^b	7.26±1.43 ^a	10.31±5.29 ^{ab}	15.17±1.98 ^b	16.28±1.54 ^b
Apparent net protein utilization	41.40±9.18 ^b	20.06±3.96 ^a	28.49±14.64 ^{ab}	41.94±5.46 ^b	45.00±4.31 ^b

Means rows with the same letter are not significantly ($P>0.05$) different

Fish Body Composition

The carcass composition of the experimental fish after the experiment revealed increase in crude protein, ash and moisture but decrease in the ether extract in all the dietary treatment over the initial carcass composition. An inverse relationship between the body lipid and moisture was apparent, which was in line with what is been obtained in previous experiment (Jauncey, 1982; Mamman *et al.*, 2013 and Jibrin *et al.*, 2018) whose used calabash for the experimental feed. The crude protein content at the beginning was 16.28% while the least crude protein content of the fish fed experimental diet was 18.81% and the highest was 24.33%, the same reported from (Jibrin *et al.*, 2018), 46.77% while the least crude protein of the fish fed experimental diet was 50.38% and the highest was 60.88%. Protein is essential in the diet of fishes as sources of amino acid which are building blocks of flesh, enzymes, eggs and some hormones (Dupree and Hunner, 1984) and also this indicates reasonable protein accumulation due to optimal utilization for growth, reproduction and survival (Alegbeleye *et al.*, 2004). The crude protein values were close to Bekibele (2005), Mamman *et al.* (2013) and Jibrin *et al.* (2018) when *C. gariepinus* was fed diet containing mucuna bean and calabash seed meal. Table 4 shows the proximate composition of the experimental fish. However, statistically there was no significant ($p>0.05$) different between the protein levels in fish placed on the dietary treatments.

Table 5: Proximate Composition (%) of experimental fish fed cotton seed meal

Parameters	Initial fish	Experimental diets				
		(0%)	(15%)	(30%)	(45%)	(60%)
Moisture	61.00	61.17±2.25	61.67±2.08	62.18±2.25	60.83±1.25	60.00±0.50
Ash	5.50	6.17±0.57	7.67±2.08	6.33±0.29	5.83±0.29	6.17±0.76
Lipid	1.00	1.67±0.29	2.00±0.50	1.67±0.29	2.17±0.58	1.50±0.50
Crude fiber	Trace	1.00±0.00	1.00±0.00	0.50±0.00	0.50±0.00	0.00±0.00
Crude protein	16.28	23.01±1.51	23.54±1.40	20.91±2.38	23.10±0.89	23.61±0.70
NFE	16.23	7.32±1.68	8.20±0.86	8.75±0.65	7.39±0.31	8.74±1.79

Means rows with the same letter are not significantly ($P>0.05$) different

Conclusion and Recommendations

From the present study, it can be concluded that the cotton seed meal (CSM) with crude protein content of 26.08% could serve as protein supplement. Diet containing 0% inclusion of Cotton seed meal had the highest crude protein (23.01%), highest Survival growth rate, highest Percentage weight gain follows by diet containing 15 and 45% level of substitution, while other diets containing 30 and 60% showed decrease in weight gain. Thus, the CSM can be incorporated in the diet of *Clarias gariepinus* x *Heterobranchius longifilis* at 15 to 45% CSM with no significant ($p<0.05$) difference in growth and other nutrients utilization. In this study, it has been shown that the whole cotton plant is a reservoir of a wide variety of compounds which have a range of biological functions and exploitable application. Cotton-seed meal in the diets of Fingerling of African catfish should be within the range of 15%-30% inclusion levels. Cotton-seed meal inclusion of 15% level should be maintained in fish feed because of its high fibre content and high protein content of about 26.08%.

References

- APHA, A. and WPCF (American Public Health Association, American Water Works Association and Water Pollution Control Federation) (1980). Standard Method for the Examination of Water and Waste Water. 17th Edition. APHA, Washington, D.C. USA. 1391 pp.
- A.O.A.C (2000). *Official Methods of Analysis*, 2nd edition. Association of Official Analytical Chemists, Washington, D.C. p.96.
- Adikwu, I.A. (1987). Studies on the utilization of dietary carbohydrates by *Tilapia*, *O. niloticus*. Ph.D. Thesis, University of Stirling, Scotland, U.K. 1-272pp.
- Adekunle, H.L., Orire, A.M., and Sadiku, S.O.E. (2012) Development of Farm made Floating Feeds for Aquaculture Species. *International Journal of Advanced Biological Research*. 2012 : 2(4): 579-583.
- Alegbeleye, W.O.A. Oresegun, Akegbejo-Samsons and S.O. Obasa (2004). Replacement of Groundnut Cake with Rubber Seed Cake in diet for Nile Tilapia. *Journal of Aquatic Science*, Vol. 19(1) 27-30.
- Anderson, J.S., Higgs, D.A.M., Beams, R.M. and Rowsshandeli, O.E (1997). Fish and meal quality assessment for Atlantic Salmon (*Salmon solar*) reared in sea water. *Aquaculture Nutrition*, 3:25-35.
- Anwa, E. P. (2006). The Effect of Processed Albizzia seed meal on the Growth and Utilization of *Clarias gariepinus* (TEUGELS) Juveniles. M.Sc. Thesis, Ahmadu Bello University Zaria, Nigeria.
- Ashiiru, A. (2011) Assessment of Cotton seed (*Gossypium species*), meal as ingredient in the diet of *Clarias gariepinus*. submit to the Department of Biological Science. Faculty of Science. Ahmadu Bello University Zaria.
- Bagenal TB, Fecundity. In: T.B. Bagenal (Ed) Methods for the Assessment of Fish Production in Freshwaters, 1978.
- Balogun, O. B., Ojo, S. B. and Olorunfemi, M. O. (2004). Characterisation of Tectonic Lineaments in The central Equatorial Atlantic region of Africa using Bouguer anomaly gravity data. *Ife Journal of Science* vol.18, no.4. 931pp.
- Bekibele, D.O. (2005). The effect of partial replacement of soya bean meal with mucuna beans on the growth and performance of *Clarias gariepinus*. In Ansa, E.A., Anyanwu, P.E., Ayonoadua, B.W., Erundu, E.S. and Dekaye, S.A. (eds.) Fish for Food and Income Generation in Nigeria. *Proceedings of 20th Annual Conference of Fisheries Society of Nigeria (FISON)*. Port Harcourt 14-18 November, 2005, River State, Nigeria, Pp.136-139.
- Cho, J. H. and Kimo. I. (2011). Fish meal-nutritive value. *Journal of Animal Physiology and Animal Nutrition*, 95(6), 685-692.
- Chow, C.Y., Cowey, B. and Watanabe, T. (1985). *Fin Fish Nutrition in Asia: Methodological Approach to Research*. International Development Research Center, Ottawa, Canada, Pp. 12-26.
- Duniya, J. N. (2006). Effect of Processed Locust Bean Seeds *Parkia biglobosa* L. Substituted Diet on the Growth of *Clarias gariepinus* Burchell. M.Sc. Thesis, Ahmadu Bello University, Zaria, Nigeria.
- Dupree HK, Hunner JV (1984). Nutrition and feeding practice. The third Report to the Fish farmers. US Dept. of Interior, Fish and Wildlife Services, Washington D.C. pp. 141-157.
- El-Saidy, D.M. and Gaber, M.M. (2002). Evaluation of Dehulled Sunflower Meal as a Partial and Complete Replacement for Fish Meal in Nile Tilapia, *Oreochromis niloticus* (L) Diets. Processing. 1st Animal Science Conference. Animal & fish Production. Mansoura, 24-25.
- FAO (2010). The State of World Fisheries and Aquaculture 2012, FAO Fisheries and Aquaculture Department. Rome, FAO. 209p. Available at
- FAO (2012). The role of aquaculture in improving nutrition. Working Document COFI/AQ/VII/2013/7, Saint Petersburg, Russia.
- Feedipedia (2016). <http://www.feedipedia.org/node/550> [09/12/2016 14:21:40]. Feeds. In R.G. Bolivar, G.C. Mair and K. Fitzsimmons Ed. Proceedings of the Sixth International Symposium on Biochemical and physico pathological species in animal production. *Vet. Human Toxicol*; 35(1):57-67.
- Gabriel, U. U., Akinrotimi, O. A., Bekibele, D. O., Onunkwo, D. N. and Anyanwu, P. E. (2007). Locally produced fish feed: potentials for aquaculture development in sub-Saharan Africa. *African Journal of Agricultural Research* 2 (7): 287-295.
- Hashim, R., Ali, A., Ng, W.K. and Lu, K.S., (2000). Effect of feeding rate on the growth, feed utilization and body composition of tropical bagrid catfish. *Aquaculture International*, 8:19-29.
- Hepher, B. (1988). *Nutrition of Pond Fishes*. Cambridge University Press, New York. 126p.
- Jibrin, H., Chidume I., Eze N.C. and Nwadu II. (2018). Effect of substituting calabash seed (*Lagenaria vulgaris*) meal for groundnut cake in the diet of catfish (*Clarias X Heterobranchus longifilis*) hybrid fingerlings. *International Journal of Fisheries and Aquatic Studies*, 6(3): 134-138.

- Jamu D.M, and Ayinla O.A (2003). Potential for the development of aquaculture in Africa *NAGA* 26:9-13.
- Jauncey K. (1982). The effect of varying protein level in the growth feed conversion and nutrient utilization of juvenile *Tilapia sarotherodon* *mussambicus*. *Aquaculture*. 27:38-42.
- Konyeme, J.E., Sogbesan, A.O. and Ugwumba, A.A.A. (2005). Growth Response and Cost benefit of *Clarias gariepinus* fingerlings fed water hyacinth (*Eichhornia crassipes*) meal as plat protein supplement. In Ansa, E.A., Anyanwu, P.E., Ayonoadua, B.W., Erundu, E.S. and Dekaye, S.A. (eds), *Fish for Food and Income Generation in Nigeria. Proceedings of 20th Annual Conference of Fisheries Society of Nigeria (FISON)*, Port Harcourt, 14-18 November, 2005, River State, Nigeria, Pp.145-148.
- Mamman, T, J.K Ipinjolu, and I, Magawata (2013). Hematological indices of *Clarias ghariiepinus* (Burchell, 1882) fingerlings fed diet containing graded level of calabash seeds (*Lagenaria vulgaris*) meal. *Journal of Biology, Agriculture and Health care*, 3(17): 100-104.
- Médale, F., Le-Boucher, R., Dupont-Nivet, M., Quillet, E., Aubin, J. and Panserat, S. 2013. Desaliments à base de végétaux pour les poissons d'élevage. *Inra Productions Animales*, 26:303 – 316.
- Mujahid, A., Abdullahi, M., Barque, A.R. and Gilani, A.H. (2000). Nutritional Value of Cottonseeds and its Derived Products: Physical Fractionations and Proximate Composition. *Asian-Australian. Journal of Animal Science*, (no 3) 348-355.
- Ojewola, G.S, Udom. S. (2005). Chemical Evaluation of the Nutrient Composition of some Unconventional Animal Protein Sources. *International Journal of Poultry Science*, 4(10), 745-747.
- Okonkwo J.C. and Oladipupo, A.O. (2010). Blood Protein Fractions of Nigerian goats: Effects of Breed and Sex, *International Journal of Biological Science*, 2: 120-127.
- Olaniyi J.O. and Akanbi W.B. (2009). Effects of cultural practices on mineral compositions of cassava peel compost and its effects on the performance of cabbage (*Brassica oleracea* L.). *Journal of Applied Biosciences* 8(1): 272-279.
- Olarinde, L. O. and Kuponiyi, F. A. (2005). Rural Livelihood and Food Consumption Patterns among Households in Oyo State, Nigeria: Implications for Food Security and Poverty Eradication in a Deregulated Economy. *J. Soc. Sci.*, 11(2): 127-132.
- Olvera-Nova MA. The dietary protein requirement of *Cichlasoma synspillum* fry. *Aquaculture Research* 1996, 167-173.
- Omitoyin, B.O. (2007). *Introduction to Fish Farming in Nigeria*. Ibadan University Press. Ibadan, Nigeria.
- Orire, A.M. and Sadiku, S.O.E. (2014). Development of Farm made Floating Feeds for Aquaculture Species. *Journal of International Scientific Publications: Agriculture and Food*. 2014: 2(1): 521-523.
- Sogbesan, A.O. and Ugwumba, A.A.A. (2008). Nutritional value of some non- conventional animal protein feedstuffs used as fishmeal supplement in aquaculture Practices in Nigeria. *Turkish Journal of Fisheries and Aquaculture Science*, 8: 159-164.
- Sotolu, A.O. and Sule, S. O. (2011). Nutritional Evaluation of Snail Offal Meal as Animal Protein Supplement in the Diets of *Clarias gariepinus* (Burchell, 1822) Fingerlings, *World Journal of Fish and Marine Sci.*, 2 (2): 103-108.
- S.P.S.S. V.23.0. (2020). Statistical Package for Social Package Sciences <http://www.winwrap.com>.
- Steel, G.D, and Torrie, J.H. (1980). *Principles and Procedure of Statistics*. A Biometrical Approach. Second edition. 633p.
- Stickney, R.R. (1979). *Principles of Warm Water Aquaculture*. John Willey and Sons. New York. 375p.
- Tacon, A.G.J. and Metian, M. (2009). Fishing for aquaculture: non-food use of small pelagic forage fish—a global perspective. *Rev. Fish. Sci.*, 17(3): 305–317.
- Webster, C.P and Chhorn, L. (2001) *Aquaculture*. In Webster, C.D and C.E Lims (Eds) *Introduction to Fish Nutrition* CABI Publishing, Oxford England.
- Wikipedia (2018). Contributors. Sokoto in Wikipedia, the free encyclopaedia retrieved. 2018; 09; 49.

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Growth response of *Heterobranchus longifilis* fingerlings fed diets supplemented with *Moringa oleifera* leaf meal as replacement of soybean meal

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Abstract

Moringa leaf meal (MLM) is a source of protein from a highly valued plant *Moringa oleifera*. Its protein has a profile of amino acids similar to that of soybean. A completely randomized design with three replicates was used in a 42 days study to determine digestibility and growth performance of 150 *Heterobranchus longifilis* fingerlings. Graded levels (0, 5, 10, 15 or 20) % of dried MLM was used to replace soybean meal in a 42.5% crude protein *H. longifilis* diet fed at 5% in the first 2 weeks and subsequently 3% body weight. The results showed that there were significant differences in weight gain (WG) and specific growth rate (SGR) of the fish with the significant highest observed in the group that fed on diet 2 with 5% MLM supplementation ($P < 0.05$) though not significantly different from the control ($P > 0.05$). The significant poorest WG and SGR were obtained in the group that fed on diet with 20% level of MLM supplementation ($P < 0.05$). There was no significant difference between treatments in terms of initial weight, feed intake and survival ($P > 0.05$). However there were significant differences in feed conversion ratio (FCR), SGR, total length and standard length among the groups that fed on diets with 15% and 20% supplementations ($P < 0.05$). The haematocrit and haemoglobin were also significantly reduced in the group that fed on the highest level of supplementation ($P < 0.05$). The in-vitro trial revealed significant reduction in digestibility with increase in MLM supplementation level ($P < 0.05$) the tannin and phytic-acid levels following the same trend. However there was no pathological defect observed in the fish from all the groups. There was no significant difference in the hepatosomatic index. The feed cost analysis showed a reduction in cost per 100kg feed with increased level of supplementation with 0.00, 11.50, 23.20, 34.00 and 50.64% for diets 1, 2, 3, 4 and 5 respectively. It was concluded that 5 – 10% MLM supplementation could be used in the diets of *H. longifilis* to obtain a reduction in cost of feeding it at 11.2% and 23.5% per 100Kg feed respectively. There is need to try other processing methods if the level could increase above that obtained from this study.

Key words: *Heterobranchus longifilis*, moringa leaf meal, soybean meal, digestibility and performance.

Introduction

Aquaculture is the fastest growing sector of the world's animal production with an annual increase of about 10% (FAO 1997, 2016). To sustain such high rates of increase in production, a matching increase in fish feed production is imperative. Because fish meal is a limited primary source and plants are widely available and reasonably priced, the use of plant protein sources in aquafeeds should be considered (State of World Fisheries and Aquaculture, 2006). Therefore, in order to attain more economically sustainable, environmentally friendly and viable production, research interest has been directed towards the evaluation and use of non-conventional sources of plant, insects and animal protein. Soybean meal is one of the most nutritious of all plant protein sources because of its high protein content, high digestibility, and relatively well-balanced amino acid profile (Lovell, 1988). Owing to its reasonable price and steady supply, soybean meal is widely used as a cost-effective feed ingredient for most aquaculture species (Storebakken, *et al.*, 2000). It is currently the most commonly used plant protein source in fish feeds (Hardy, 2010). However, soybean meal use in animal feeds competes with human food use, and hence there is a need to identify other protein-rich plant resources that could be used in fish diets. Another potential alternative plant protein source for fish feeds is moringa (*Moringa oleifera*). This plant is receiving much attention because its leaves, flowers and seeds can all be used as food (Makkar and Becker, 1997). Moringa leaf contains crude protein (CP) with about 260g/kg of leaf, of which about 87% is true protein (Makkar and Becker, 1996). Essential amino acids found in moringa leaf are methionine, cysteine, typtophan and lysine (Makkar and Becker, 1996). Analyses of the leaf composition have revealed them to have significant quantities of vitamins A, B and C, calcium, iron and protein. According to Optima of Africa, Ltd., a group that has been working with the tree in Tanzania, "25 grams daily of Moringa Leaf Powder (MLP) will give a child" the following recommended daily allowances: Protein 42%,

Calcium 125%, Magnesium 61%, Potassium 41%, Iron 71%, Vitamin A 272%, and Vitamin C 22%. A comparison between the amino acid composition of raw moringa leaf and that of soybean revealed an almost identical pattern of the essential amino acids (Foidl *et al.*, 2001). There is an abundant total amount of these essential amino acids plenty in the leaf that can be used as animal feed (Afuang *et al.*, 2003). The objective of this present experiment was to investigate the effect of different levels of dietary moringa leaf meal as a partial replacement of full fat soybean meal in the diet of *Heterobranchus longifilis*, (giant African catfish) fingerlings on the growth performance, nutrient digestibility, haematology and liver histopathology.

Materials and methods

Preparation of *Moringa oleifera* leaf meal (MLM): The *M. oleifera* leaves used in the diets was harvested whole in NIFFR Estate, New Bussa, Niger State and air dried under the shade. The whole leaves harvested were allowed to wilt under the shade overnight after which mere shaking it help the leaflets to drop out of the stalk before final drying. This was to avoid the stalk of the leaves mixing up with the leaflets needed and reduce fibre contribution from the MLM into the diets. The leaflets were milled to powder after they have properly dried which was used for the preparation of the experimental diets.



Leaflets

Plate 1: *Moringa oleifera* Leaf

Experiment:

Three Hundred *Heterobranchus longifilis* fingerlings were acquired and acclimatized for two weeks before selection and subjection to the experiment. Completely randomized design with three replicate groups was used to study the response of 150 *Heterobranchus longifilis* fingerlings to diets supplemented with graded levels (0, 5, 10, 15 or 20)% of *Moringa* leaf meal (MLM) to replace soybean meal in a soybean and fish meal based diet together with other ingredients (Table 1). The 42 days study was carried out in an aerated aquaria using indoor at the fish nutrition laboratory in NIFFR feed mill complex. Diet 1 with a zero supplementation served as control. Chemical analysis such as phytochemicals in leaf considering tannin and phytic acid determination, proximate composition (AOAC, 2000), haematology, histopathology of feed and fish samples were carried out. Digestibility was also assessed. Fish were fed at 5% body weight at commencement of the study in the first 2 weeks but was reduced to 3% body weight when much leftover feeds were observed which could be due to *Heterobranchus* feed consumption nature which is poor. The daily rations were divided into two instalments, supplied morning (8.00 - 9.00 am) and evening (6.00 – 7.00 pm). Siphoning of the bottom of the aquaria was carried out each morning and addition of freshwater to maintain water level before feeding the fish. Fortnight sampling was adopted for feed adjustments, fish observation and total cleaning of the aquaria. Water quality was monitored in the course of the study using easy test kit. Feed cost was calculated based on the prevailing market prices of the ingredients at the period of experimentation. Statistical analysis was carried out on the data obtained at the end of the study.

In-Vitro protein digestibility

The experimental diets were measured in triplicates by cleavage peptides (Gimenez *et al.*, 1999). 20 mg of each diet was added with 12 ml of 50mM phosphate buffer (pH 7.5) and incubated overnight at 30°C. In-vitro digestion was started by adding 500µl of crude enzyme extract and incubated for 24 hours at 30°C. After digestion, 1ml of each digested mixture was determined of cleavage peptides by measuring absorption at 750nm and converted into mg protein using a standard curve developed from the principle reported by (Lowry *et al.*, 1951)

Table 1: Composition of 42.5% Crude Protein Experimental diet

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Moringa leaf meal	0.00	5.00	10.00	15.00	20.00
Full fat soybean meal	20.00	15.00	10.00	5.00	0.00
Basal feed	80.00	80.00	80.00	80.00	80.00
Total	100.00	100.00	100.00	100.00	100.00

* Provides per kg diet: Vitamin A, 125000 IU, Vitamin D₃ 2500 IU, Vitamin E 40mg, Vitamin K 2mg; Vitamin B₁ 3mg; Vitamin B₂ 5.5mg; Choline chloride 500mg; Niacin 35mg; Vitamin B₆ 5mg; Vitamin B₁₂ 0.025mg; Folic acid 1mg; Biotin 0.08mg; Manganese 120mg; Iron 100mg; Zinc 80mg; Iodine 1.8 mg; Calcium pantothenate 11.5mg; Copper 8.5mg; Cobalt 0.3 mg; Selenium 0.12 mg; vitamin C 2000mg, Antioxidant 120 mg;

Results

The results of diets' proximate composition, growth performance of fish, in-vitro digestibility, and antinutritional factors in the diets are presented in the tables 2-5 below. The growth performance results showed that there was significant difference in weight gain of the fish with the significant highest gain observed in the group that fed on diet 2 with 5% supplementation ($P < 0.05$). The significant poorest weight gain was obtained in the group that fed on diet 5 with highest (20%) level of MLM supplementation ($P < 0.05$). There was no significant difference between treatments in terms of initial weight, feed fed and survival ($P > 0.05$). However there was significant difference in FCR, Specific growth rate, total length and standard length among the groups that fed on diets 4 and 5 with 15% and 20% supplementations respectively ($P < 0.05$). The significant poorest specific growth rate (SGR) was observed with the group that fed on the highest MLM supplementation ($P < 0.05$) while the significant highest SGR was obtained with the groups that fed on 5% MLM supplementation though it was not significantly different from the control group. The haematocrit and haemoglobin were also significantly reduced in the group that fed on the highest level of supplementation ($P < 0.05$). The in-vitro trial revealed significant reduction in digestibility with increase in MLM supplementation level ($P < 0.05$). The tannin and phytic-acid levels followed the same trend. However there was no pathological defect observed in the fish from all the groups. There was no significant difference in the hepatosomatic index. The cost analysis showed a reduction in cost per 100kg feed with increased level of supplementation with 0.00, 11.50, 23.20, 34.00 and 50.64 % for diets 1, 2, 3, 4 and 5 respectively. The results of the water qualities monitored have means within the range suitable for good growth of catfish with temperature 27.5°C, dissolved oxygen 4.6mg/l, pH 7.51, NH₃-N 0.34mg/l and NH₂-N 0.026mg/l.

Discussions

The results of this study indicated that *M. olifera* leaves possess the potential to partially replace soybean meal in any soybean and fishmeal base diet for giant African catfish (*H. longifilis*) without adversely affecting growth performance, digestibility and pathology of the fish. This is in agreement with earlier studies on *Oreochromis niloticus* by Richter *et al.* (2003) and Abo-State *et al.* (2014) who used MLM to replace fishmeal in the diets of the fish and found out that MLM could replace fishmeal up to 10% and 8% respectively in tilapia. Moringa leaf meal (MLM) could be used to reduce pressure on soybean meal. Hardy 2010 noted that soybean is currently the most commonly used plant protein sources in fish feed and there is competition with human use. Using MLM to reduce pressure on soybean will be possible because comparison between the amino acids of MLM and soybean revealed an almost identical pattern of all the essential amino acids (Foidl *et al.*, 2001). The observation of reduced growth performance, digestibility and poorer FCR at higher inclusion level in this present study is an indication that there is a limit to the extent which MLM could be included in the diet of giant African catfish to avoid negativity in performance. This is similar to what was earlier reported on *O. niloticus* (Richter *et al.*, 2003 and Abo-State *et al.*, 2014). The poor performance at higher levels might not be unconnected to the antinutritional factors present in the raw moringa leaf. Although the MLM used in this study was air dried before use, the phytochemical analysis revealed that the phytic acids and tannin were still present in the diets though at low levels. The poor performance observed in the groups that fed on diets with higher inclusion levels of MLM might be related to the likely interaction of the antinutritional factors with utilization of other nutrients in the feeds (Makkar and Becker, 1996). The poor Hb and PCV levels obtained in the groups that fed on the highest MLM supplementation level might have been due to interactive effect of phytochemicals against the fish natural body functional ability to neutralise or suppress the deleteriousness of certain ingested chemicals. The appreciable digestibility of protein obtain in this study might be due to the drying process the leaf undergo before its use, the equal fishmeal levels and palm oil as a source of lipids in the diets with the fact that it is plant protein portion that was replaced. Palm oil has a natural tendency to neutralize the efficacy of poisonous substances like the one that could result from the antinutritional factors such as the tannins and phytic substances in the MLM. It had also been noted that antinutrients such as tannins and saponins inflicts bitterness in feeds and could results in poor consumption (Afuang *et al.*, 2003) due to

reaction of the chemosensory receptors (Madalla, 2008). That might happen at high levels of inclusion which could result to high concentration of those antinutrients and subsequent effective bitterness since the intake in this study did not exhibit such criteria as there was no significant difference in feed intake. Although increased level resulted into poor feed conversion ratio which might not be unconnected to the carnivorous-ominivorous nature of the giant African catfish and tannins interaction with utilization of nutrients in feeds. The effective cost reduction also observed in the formulations with MLM is an indication that it could be used to replace some soybean in the diets of giant African catfish at the optimum level of 5-10% replacement.

In conclusion, MLM could be used to partially replace up to 5 - 10% of the full fat soybean meal in the diet of giant African catfish, *Heterobranchus longifilis* fingerlings without reduction in the growth performance of the fish. The MLM use will also lead to reduction in cost of fish feed. Using the best performing supplementation level (5%) will result to a cost reduction of 11.5% per cost of 100Kg feed base on the formulations used in this study while the 10% optimum level of supplementation will result to feed cost reduction of 23.2% per cost of 100Kg feed. The cost to benefit ratio obtained in the study encourages the use of 5% level of replacement. There is need to subject moringa leaves to other processing methods for another trial to see if there could be improvement from what was obtained in this present study. There is need to evaluate the response of *Clarias* species to moringa leaf inclusion in the diet.

Table 2: Proximate composition of the Experimental diets

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Moisture Content %	6.02	6.08	5.89	6.55	6.01
Crude Protein %	44.78	42.69	42.56	41.89	41.69
Crude Fat %	13.50	13.35	13.89	12.73	12.05
Crude Fibre%	2.02	2.41	3.54	4.98	6.02
Ash %	7.65	7.77	7.82	7.89	7.65
NFE %	26.03	27.70	27.30	25.96	26.58

Table 3: Growth performance of *Heterobranchus longifilis* fingerlings fed diets with graded level of MLM as replacement for toasted full fat soybean meal (0 – 6 weeks).

Parameter	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Initial Weight (g /Fish)	9.25 ±0.34 ^a	9.14 ±0.55 ^a	8.96 ± 0.22 ^a	8.61± 0.16 ^a	9.11± 0.41 ^a
Weight Gain (g /Fish)	16.14 ±0.70 ^{ab}	23.63±12.76 ^a	16.41± 5.61 ^{ab}	16.71±4.81 ^{ab}	8.54±3.36 ^c
Feed Consumed (g /Fish)	15.50±3.45 ^a	22.45±13.31 ^a	16.37±8.04 ^a	17.38±16.06 ^a	10.33±3.9 ^a
Feed Conversion Ratio	0.96±0.14 ^a	0.93±0.05 ^a	1.00±0.10 ^a	0.97±0.15 ^a	1.2±0.02 ^b
SGR (%/day)	2.38±0.05 ^{ab}	2.90±0.94 ^a	2.45±0.55 ^{ab}	2.53±0.44 ^{ab}	1.54±0.46 ^b
Survival (%)	70.00±00 ^a	45.83±36.08 ^a	66.67±14.43 ^a	58.33±28.86 ^a	66.67±14.43 ^a
Total Length (Cm)	9.70±0.26 ^b	10.78±0.89 ^a	10.55±0.26 ^{ab}	9.75±0000 ^b	10.21±0.40 ^{ab}
Standard Length (Cm)	8.00±0.00 ^c	9.10±0.81 ^a	8.88±0.43 ^b	8.25±0.00 ^c	8.77±0.25 ^{ba}
Haematocrit (%)	23.76±1.16 ^a	24.35±1.05 ^a	24.67±1.17 ^a	23.86±2.66 ^a	19.02±1.23 ^b
Haemoglobin (mg/dl)	11.20±2.32 ^a	11.05±2.15 ^a	11.40±2.20 ^a	10.80±1.20 ^a	7.02±2.34 ^b
% Reduction in N/100Kg Feed	00	11.50	23.20	34.00	50.64

a-c Means plus standard deviation within rows with different superscript(s) significantly different (P<0.05). SGR = Specific growth rate

Table 4: Phytochemical contents of Moringa leaf and experimental diets

Parameters % MLM	Moringa leaf	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Total Tannin	2.82±0.69	0.82±0.06 ^c	2.09±0.27 ^b	2.36±0.12 ^{ab}	2.51±0.28 ^a	2.60±0.24 ^a
Phytic acid	0.49±0.14	0.46±0.05 ^c	1.15±0.13 ^b	1.29±0.05 ^{ab}	1.40±0.13 ^a	1.48±0.14 ^a

a-c Means plus standard deviation within rows with different superscript(s) significantly different (P<0.05)

Table 5: Digestibility of the Diets fed to *Heterobranchus longifilis* fingerlings (0 - 6weeks)

Parameters	Diet 1 (Control)	Diet 2	Diet 3	Diet 4	Diet 5
Digestibility coefficient (%)	83.65 ± 1.59 ^a	79.29±0.36 ^a	75.05±1.25 ^b	71.45±1.78 ^b	68.34±1.68 ^c
Protein digestibility (%)	92.67±0.55 ^a	91.24±0.43 ^a	91.37±34 ^a	88.26±0.27 ^b	86.39±0.23 ^c

a-c Means plus standard deviation within rows with different superscript significantly different (P<0.05)

References

- Abo-State, M. A., Ragab, A. M.E., Nour Sh. El-Gendy, Farahat, L. A. and Madian. H. R. (2014): Bioethanol production from rice straw enzymatically saccharified by fungal Isolates, *Trichoderma viride* F94 and *Aspergillus terreus* F98. Soft 3, 19-29 <http://dx.doi.org/10.42361Soft> 2014.32003.
- Afuang, W., Siddhuraju, P. and Becker, K. (2003): Comparative nutritional evaluation of raw, methanol extracted residues and methanol extracts of moringa (*Moringa oleifera* Lam.) leaves on growth performance and feed utilization in Nile tilapia (*Oreochromis niloticus* L.). Aquaculture Research. 34, 1147 – 1159.
- A.O.A.C. (2000): Association of Official Analytical Chemists. 17th Edition, A.O.A.C., Washington DC. Pg 21,447.
- Food and Agricultural organization FAO (1997): Fisheries Improvement by Stocking at High Altitudes for Inland Development (FISHAID) Project, Papua New Guinea. FI:PNG/93/007 Terminal Report. Rome.
- Foidl, N. H., Makkar, P. S. and Becker, K. (2001): The potential of *Moringa oleifera* for agricultural and industrial uses L. J. Fuglie (Ed.), The Miracle Tree, CTA and CWS, Senegal pp. 45 – 77.
- Gimenneze, A. V. F., Fernandez, I., Preciado, R. M., Oliva, M., Tova, D. and Nolasco, H. (1999): The activities of digestive enzyme during the molting stage of the arche swimming *Callinectes arcatus* or day, 1863. Bulletin of Marine Science 65:1 – 9.
- Hardy, R. W. (2010): Utilization of plant proteins in fish diets: Effect of global demand and supplies of fishmeal. Journal of Aquaculture Research 41(5):770 – 776.
- Lovell, R. T. (1988): Use of soybean products in diets for aquaculture species. Journal of Aquaculture Production 2, 27 – 52.
- Lowry, O. H., Rosebrough, N. S., Farr, A. L. and Randall, R. S. (1951): Protein measurement with the Folin Phenol reagent. The Journal of Biological Chemistry 193, 265 – 275
- Madalla, N. (2008): Novel feed ingredients for Nile tilapia (*Oreochromis niloticus* L.). In: PhD Thesis, Inst. Aquaculture, Univ. Stirling, Scotland, UK. pp196
- Makkar, H. P. S. and Becker, K. (1996): Nutritional value and antinutritional compounds of whole and ethanol extracted *Moringa oleifera* leaves. Animal Feed Science and Technology 63, 211 – 228.
- Makkar, H. P. S. and Becker, K., 1997. Nutrients and antiquality factors in different morphological parts of the *Moringa oleifera* tree, Journal of Agricultural Science, 128, 311–332
- Richter, N., Siddhuraju, P. and Becker, K. (2003): Evaluation of nutritional quality of moringa (*Moringa oleifera* Lam.) leaves as alternative protein source for tilapia (*Oreochromis niloticus* L.). Aquaculture. 217, 599 – 611.
- State of World Fisheries and Aquaculture (2006): FAO Fisheries Technical Paper. No. 500. Rome, Italy. Internet: <http://www.fao.org/docrep/fao>.
- Storebakken, T., Refstie, S. and Ruyter, B. (2000): Soy products as fat and protein sources in fish feeds for intensive aquaculture. J. K. Drackley (Ed.), Soy in Animal Nutrition. Federation in Animal Science Societies. Savoy, IL, USA. pp 127 – 170.

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Growth Performance of *Clarias gariepinus* Fingerling Fed with different Inclusion levels of African rosewood (*Pterocarpus mildraedii*) leaves Meal

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Abstract

This research was carried out to determine the growth performance of *Clarias gariepinus* fingerling fed with different inclusion levels of African rosewood (*Pterocarpus mildraedii*) leaves. Two hundred and forty (240) fingerlings of *Clarias gariepinus* fish of mean weight 7.01 ± 0.00 g were procured from Regina Paci Fish Farm and randomly stocked at 10 fishes per plastic bowel at four (4) treatment levels, each with 3 replicates. The effect of partial replacement of the fish meal with African rosewood (*Pterocarpus mildraedii*) leaves on the growth variables and nutrient utilization, were assessed. Four practical diets with graded replacement levels of fish at 0%, 2%, 4% and 6% were formulated and fed to *C. gariepinus* fingerlings for 56 days at 5% biomass. The dietary groups were designated as D1 (control), D2 (2%), D3 (4%) and D4 (6%) inclusion levels. The results obtained from the study indicated that *Pterocarpus mildraedii* leaf when used as a replacement for fish meal in the diet of *Clarias gariepinus* fingerlings can be utilized by the fish up to 40% inclusion level without adverse effect on growth. The highest values of growth performance were: final weight 27.98 ± 7.73 g, weight gain 20.97 ± 7.74 g, PER 1.22 ± 0.23 and the best FCR 0.20 ± 0.02 were recorded in D3 (4% inclusion of *Pterocarpus mildraedii*) and closely followed by the D2 (2%) treatment group. There was no significant difference ($P > 0.05$) between the values in the control and treatments D2 (2%) and D3 (4%). The results obtained from this study therefore shows that *Pterocarpus mildraedii* leaf can be used as an alternative source for partial replacement of fish meal up to 4% inclusion level in the culture of *Clarias gariepinus* without negative effect on the growth performance.

Keyword: Growth Performance, *Clarias gariepinus*, *Pterocarpus mildraedii*

Introduction

The African catfish (*Clarias gariepinus* Burchell, 1822) locally referred to as mudfish belongs to the Phylum Chordata; Class Osteichthyes; Order Siluriformes; Family Clariidae and Genus *Clarias*. In Africa, more than one hundred different species (100) have been identified for which about nine species features prominently in African aquatic ecology. These are the *Clarias gariepinus*, *Clarias anguillaris*, *Clarias pachynema*, *Clarias macromystax*, *Clarias agbonyiensis*, *Clarias buthupogon*, *Clarias lazera*, *Clarias macracanthus* and *Clarias tsanensis* (Idodo-Umeh, 2003). Morphologically, the *Clarias gariepinus* is a scale less fish with smooth skin and soft ray fin, dorsal-ventrally flattened bony head and elongated body (Yinka et al. 2005 and Idodo-Umeh, 2003) Its dorsal fin has about 61-80 rays and anal fin of 50 -65 rays. Its head is between rectangular and pointed dorsal outline with broad snout. It is often described as depressed and long body shaped fish.

Feed is one of the major inputs in aquaculture production (Jamiu and Ayinla, 2003). Fish feed technology has become one of the least developed sectors of aquaculture particularly in Africa and other developing countries of the world (Gabriel et al., 2007). Nutritionists all over the world are in constant search of the dietary feedstuff sources that will maximize growth within the shortest possible time at the cheaper cost (Adewolu, 2008). This is because the traditional or conventional feedstuffs are becoming costly and less available, hence the need for unconventional feedstuff sources, especially those of plant origin (Tewe, 2004). Most leaf meals such as in cassava, alfalfa, *Carica papaya*, *Leucaenaleucocephala* and *Ipomeabatatas* have been reported to provide essential nutrients required in livestock feeds, including fish (Yousif et al, 1994; Ali et al, 2003; Bairagiet al, 2004; Adewolu, 2008). *Leucaenaleucocephala* is available in almost every geographical location and grows fast (Amisahet al, 2009; Dorothy et al, 2018). Its leaves are a good source of protein and needs to be examined in greater detail on its suitability for the African catfish, *Clarias gariepinus* (Amisahet al, 2009).

Fishmeal is usually imported from Israel and Brazil and is used in commercial production of catfish feed as the major source of protein (FAO, 2013). This has created a sustained dependence on these countries for the supply of fishmeal (FAO, 2013). The high cost of fishmeal makes commercial production of catfish capital intensive as it

accounts for between 40 and 60 % of variable operating cost (De silva and Anderson 1995). Leafy vegetables are important items of diet in many Nigerian homes (Dorothy *et al*, 2018). Apart from the variety which they add to the menu (Mepha and Eboh, 2007; Subukolaet *al.*, 2007), they are valuable sources of nutrients especially in rural areas where they contribute substantially to protein, minerals, vitamins, fibers and other nutrients which are usually in short supply in daily diets (Mohammed and Sharif, 2011). In many developing countries the supply of minerals is inadequate to meet the mineral requirements of farm animals and rapidly growing population. Minerals cannot be synthesized by animals and must be provided from plants or mineral-rich water (Anjorin *et al.*, 2010).

Materials and Methods

Study Area

The experiment was carried out at the Department of Fisheries and Aquaculture of Ebonyi State University, Abakaliki, Ebonyi State. Abakaliki is situated between 06° 19.370" North latitudes and 008° 07.692" East longitudes. There are two distinct seasons within the zone; a wet season that starts from April to August and the dry season (Ude, 2011). The rainfall pattern is bimodal (April- July and September- November) with a short break in August. The annual rainfall ranges from 1,800mm to 2,000mm and mean annual temperature of 27 and 31 with relative humidity ranging between 60-80% during the rainy season.

Processing of African Rose Wood Leaf Meal

African Rose wood leaves were collected from a forestry area within the University premises. The leaves were washed, air-dried and ground into powder using milling machine before incorporating in the diet at different inclusion levels.

Procurement of Feedstuff

Feed ingredients used in the formulation of the experimental diet include; soybean meal, fish meal, and maize which were purchased from Abakpa market in Abakaliki and ground using hammer mill. Vitamin and minerals Premix, methionine, lysine and vegetable oil were also obtained from a feed store.

Experimental Diet

The experimental diets were formulated at the Department of Fisheries and Aquaculture with the inclusion of African Rose wood leaf meal at 0%, 2%, 4% and 6% for D1, D2, D3 and D4 respectively. The feed ingredients were bound together using cassava starch as a binder, pelletized, air-dried with each treatment diet packaged in a cellophane bag and stored in a cool dried place. The feed were pelleted using fabricated pelleting machine at the feed mill unit, sun- dried, packaged in bags and stored in a dry place away from moisture. The formulation of the feed was based on the proximate composition of the feed ingredient (Table 1). The test diets were fortified with Vitamin/mineral, Premixes, binder, oil and salt. The gross percentage composition of each experimental diet was derived (Table 1) using Pearson Square Method (Pearson, 1979) to produce a diet of 42% crude protein.

Table 1. Gross Composition (g/kg) of Experimental Diets Containing *P. Mildraedii* leaf Meal Fed to *Clarias gariepinus*.

Ingredients	D1	D2	D3	D4
Fish meal	230.00	230	230	230
<i>P. mildraedii</i> inclusion level	0.00	20	40	60
MaizeMeal	160.00	160	160	160
Soybean	300.00	300	300	300
GNC	250.00	230	210	190
Palm oil	30.00	30	30	30
Mineral & Vit. Premix	20.00	20	20	20
Salt	10.00	10	10	10
% <i>P. mildraedii</i> inclusion level	0	2	4	6

Experimental Fish

A total of two hundred and forty (240) African Catfish *Clarias gariepinus* fingerlings with 7.01±0.00g mean weight were procured from Regina Pacie fish farm, Abakaliki in Ebonyi State and acclimated in grow out pond for 3hours at the Departmental farm. This research was carried out for fifty six days (56 days).

Experimental Design

The experiment was carried out using Completely Randomized Design (CRD). The fish were starved for 48 hours to evacuate the stomach content and eliminate variation in weight due to residue feed in the gut prior to experiment. A total of four diets were formulated using four treatments and three replications; feed with 0% African rosewood leaf (D1) as control, feed with 2% African rosewood leaf (D2) as T1, feed with 4% African rosewood leaf (D3) as T1 and feed with 6% African rosewood leaf (D4) as T4.

Feeding and Sampling

The fish were randomly stocked at a density of 10 fish/m² and fed twice daily (8:30am and 4:00pm) at 5% body weight. Fish mortality was monitored daily, total fish weight in each tank was determined at two weeks intervals and the amount of diet was adjusted according to the new weight. Sampling was done before the application of feed to avoid the biasness of weight due to presence of excessive feed.

Growth Parameters

To determine the growth response of the fish, the following parameters were calculated at the end of the study (Ogunji, 2004):

Mean Weight Gain (g) (MWG)

$$\text{MWG} = \frac{\text{WT}_2 - \text{WT}_1}{N} \dots\dots\dots 1$$

Where Wt1 = initial mean weight of fish at time T1

Wt2 = final mean weight of fish at time T2

N = Number of days

Protein Efficiency Ratio (PER)

$$\text{PER} = \frac{\text{fish Weight Gain (g)}}{\text{Protein intake (g)}} \dots\dots\dots 2$$

Where;

$$\text{Protein intake} = \frac{\% \text{ protein in feed} \times \text{total diet consumed}}{100}$$

Specific Growth Rate (SGR)

$$\text{SGR} = \frac{100 (\text{Loge } W_f - \text{Loge } W_i)}{\text{Time (days)}} \dots\dots\dots 3$$

Wf = final average weight at the end of the experiment

Wi = initial average weight at the beginning of the experiment

Loge = Natural Logarithm reading

Survival Rate (%)

$$\text{Survival Rate (\%)} = \frac{\text{Number of fish that survived} \times 100}{\text{Total number of fish stocked}} \dots\dots\dots 4$$

Mineral Composition

Mineral components such as sodium, calcium, iron, magnesium, potassium, phosphorus and ascorbic acid were analyzed on the leave and recorded.

Phytochemical Parameters

Phytochemical parameters including carotenoids, tannins, saponins, alkaloids, flavonoids, phenols, cyanogenic glucosides and xanthone were also analyzed during the experiment.

Water Quality Analysis

Physicochemical analysis of water was measured weekly during the duration of the study. The following parameters were tested for; water temperature, hydrogen ion concentration (pH), Nitrate, Nitrite and dissolved oxygen (DO) using dissolved oxygen test kit and other water testing parameters following the manufacturer's instructions.

Statistical Analysis

Data on growth performance of *Clarias gariepinus* fingerling fed with different inclusion levels of African rosewood leaves collected from the experiment were subjected to one-way analysis of variance (ANOVA), using

SPSS (Statistical package for Social Science 2006, version 22) and the differences among treatments were separated using Duncan multiple range test (Duncan, 1955).

Results

Water Quality

Water quality parameters recorded during the experiment are presented in Table 2. There was no significant difference ($P>0.05$) in all the parameters. The values observed were within the tolerance range of *Clarias gariepinus*. The highest mean temperature occurred in diet T3 (28.00 ± 0.00) followed by diet T1 and T4 (27.67 ± 0.33), while the least mean temperature was observed in T2 (27.33 ± 0.33). The pH was between 6.50 ± 0.29 (T3) to 6.83 ± 0.17 (T2), dissolved oxygen ranged from 6.67 ± 0.17 mg/l (T3 and T4) to 6.83 ± 0.17 mg/l (T1 and T2) respectively.

Proximate Composition of *Pterocarpusmildraedii* Leaf Meal

The result of the proximate analysis of the *Pterocarpusmildraedi* leaf meal is shown in Table 3 below. *Pterocarpusmildraedi* leaf meal contains a crude protein level of 20.50%, crude fat 3.15%, crude fibre 17.40%, total ash 5.81% and 34.87% for carbohydrate.

Mineral Composition *Pterocarpusmildraedii* Leaf

The mineral composition of *Pterocarpusmildraedii* is presented on table 4. The analysis indicated that chromium and lead are absent in the mineral composition of *Pterocarpusmildraedii*. There is also a high level of magnesium content (43.05%) and sodium (31.15%) as indicated by the result of the analysis.

Phytochemicals Properties *Pterocarpusmildraedii*

The result of the phytochemical analysis showed that steroids were absent in the composition of *Pterocarpusmildraedii*. *Pterocarpusmildraedii* contains 4.12% of tannins. Aboweiet al., (2011) in their study reported that presences of anti-nutritional factors such as alkaloids, glycosides, oxalic acids, phytates, protease inhibitors, haematoglutinin, saponin, momosine, cyanoglycosides etc. and their imbalances in some essential amino acids, fatty acids and micronutrients may lead to reduction in growth performance of fish.

Growth Performance of *C. gariepinus* Fingerlings fed *Pterocarpusmildraedii* Leaf Meal based Diet

The table below shows the performance of the experimental fish with regards to the growth and nutrient utilization parameters. There was no significant difference ($P>0.05$) on the mean initial weight (7.01 ± 0.00 g), which ensured homogeneity of fingerlings at the onset of the feeding trial. Mean final weight ranged from 18.01 ± 0.83 g (T4) to 27.98 ± 7.73 g (T3) was not significantly different ($P<0.05$) among the experimental diets and control (Table 6).

Table 2. Water Quality Parameters

Parameter	DO (mg/l)	Ph	Temp. (°C)
T1	6.83 ± 0.17	6.67 ± 0.17	27.67 ± 0.33
T2	6.83 ± 0.17	6.83 ± 0.17	27.33 ± 0.33
T3	6.67 ± 0.17	6.50 ± 0.29	28.00 ± 0.00
T4	6.67 ± 0.17	6.67 ± 0.17	27.67 ± 0.33

Means within column with different superscripts are significantly different ($P<0.05$).

Table 3. Proximate Composition (%) of *Pterocarpusmildraedii* Leaf Meal

Parameters	Composition (%)
Crude Protein (%)	28.50
Moisture (%)	17.10
Crude Fibre (%)	17.40
Crude Fat (%)	3.15
Ash (%)	5.81
Carbohydrate (%)	34.87

Table 4. Minerals Composition of *Pterocarpusmildraedii* Leaf Meal

Element	Composition
Calcium (Ca)	4.02
Copper (Cu)	0.25
Zinc (Zn)	1.40
Magnesium (Mg)	43.05
Potassium (K)	0.31
Chromium (Cr)	0.00
Iron (Fe)	0.55
Manganese (Mg)	0.16
Lead (Pb)	0.00
Sodium (Na)	31.15

Table 5. Phytochemicals Properties of *Pterocarpusmildraedii* Leaf Meal

Parameter	Composition (%)
Alkaloids	2.70
Glycosides	0.18
Sponins	1.30
Tannins	4.12
Flavoids	0.20
Steroids	0.00
Phenols	0.20

Table 6. Growth Performance of *C. gariepinus* Fingerlings fed *Pterocarpusmildraedii* Leaf Meal based Diet

Parameter	T1 (0%)	T2 (2%)	T3 (4%)	T4 (6%)
IW(g)	7.01±0.00 ^a	7.01±0.00 ^a	7.01±0.00 ^a	7.01±0.00 ^a
IL (cm)	9.76±0.01 ^a	10.33±0.01 ^a	10.67±0.03 ^a	10.47±0.02 ^a
FW(g)	19.78±5.32 ^a	25.15±3.81 ^a	27.98±7.73 ^a	18.01±0.83 ^a
FL (cm)	13.83±0.11 ^a	14.00±0.06 ^a	15.90±0.24 ^b	14.40±0.20 ^a
WG (g)	16.00±2.02 ^a	18.14±3.81 ^a	20.97±7.74 ^a	11.00±0.83 ^b
FCR (%)	0.22±0.02 ^a	0.29±0.04 ^a	0.20±0.02 ^a	0.94±0.10 ^b
PER (%)	0.56±0.12 ^a	0.74±0.23 ^{ab}	1.22±0.23 ^b	0.16±0.03 ^a
SGR (%)	3.42±0.64 ^a	3.06±0.55 ^a	3.34±0.50 ^a	2.07±0.03 ^a
Survival Rate (%)	56.67±5.77 ^b	26.67±3.33 ^a	50.00±10.00 ^{ab}	50.00±5.77 ^{ab}

Means within rows with different superscripts are significantly different ($P < 0.05$).

IW = Initial weight, IL= Initial length, FL= Final length, FW = Final Weight, WG = Weight Gain, FCR = Food Conversion Ratio, PER = Protein Efficiency Ratio, SGR = Specific Growth Rate.

Discussion

The result obtained for the growth response, nutrient utilization and survival parameters of fish fed *Pterocarpusmildraedi* based diet are shown in Table 5. The fish fed 2% *Pterocarpusmildraedi* leaf meal diet gained 20.97±7.74g, while the fish fed control diet gained 16.00±2.02g. The values for weight gain obtained for the fish fed control diet, 2% and 4% *Pterocarpusmildraedi* leaf meal diet were not significantly different ($P > 0.05$) but were significantly different ($P < 0.05$) when compared with fish fed 6% *Pterocarpusmildraedi* leaf meal diets. This followed a similar trend with the work of Anyanwuet *al.* (2012) who reported that weight gained by *Clarias gariepinus* decreased with increased inclusion level of cassava leaf meal. However, Bichi and Ahmad (2010) obtained the greatest weight at 66.7% inclusion level of cassava leaf meal. The decrease in mean weight gain of fish at 6% inclusion was probably caused by reduced palatability of the diet. Specific growth rate ranged from 2.07±0.03g – 3.42±0.64g in the treatment containing 6% inclusion of *Pterocarpusmildraedi* leaf meal and control diet respectively. This parameter was significantly affected by the treatment levels as indicated by decreasing trend observed from the result (Table 6). These results compared favourably with 1.65 to 2.96 reported by Anyanwuet *al.*, (2012) for *Pterocarpusmildraedi* leaf meal inclusion levels.

There was no significant difference ($P>0.05$) in the feed conversion ratio (FCR) in the fish fed control diet, 2% and 4% *Pterocarpusmildraedi* leaf meal diet but there was a significant difference when compared with the fish fed the diets containing 6% *Pterocarpusmildraedi* leaf meal. The ability of an organism to convert nutrients especially protein positively influences its growth performance. This was justified by the growth performance in fish fed 2% *Pterocarpusmildraedi* leaf meal inclusion. Lower feed conversion ratio indicates better utilization of the feed by the fish. According to De Silva and Anderson (2001), feed conversion ratio is between 0.2 to 1.8 for fish fed carefully prepared diets, and the results from the present study fall within this range. The least mean feed conversion ratio was observed in diet T3 (0.20 ± 0.02), indicating that fish in this diet had the best utilization of the feed.

The highest value of 1.22 ± 0.23 recorded for protein efficiency ratio (PER) was observed in fish fed diet containing 2% *Pterocarpusmildraedi* leaf meal and lowest value of 0.16 ± 0.03 was recorded in fish fed diet containing 6% *Pterocarpusmildraedi* leaf meal. This is in agreement with the result reported by Hassan *et al.*, (2017). Hassan *et al.*, (2017) reported that cassava leaf meal can be used up to 20% replacement in the diets for African catfish without negatively impacting the growth and nutrient utilization. Cassava leaf meal has been successfully used to replace maize in *Clarias gariepinus* fingerlings 50% replacement, *C. gariepinus* advanced fry and hybrid catfish (Hetero X *Clarias*) 66% replacement (Olurinet *et al.*, 2006; Olukunle, 2006; Abu *et al.*, 2010). Experiments on *Tilapia zillii* also resulted that sweet potato leaf meal could be included up to 15% level in diets without compromising the growth and feed efficiency (Adewolu, 2008). Survival rate (SR) was highest in fish fed with control diet and the lowest (26.67 ± 3.33) in fish fed 2% of *Pterocarpusmildraedi* leaf meal based diet.

Conclusion and Recommendations

The leaves of *Pterocarpusmildraedi* have the potential to make considerable contributions to growth of the African catfish. It also has the potential to partially replace fish meal in a feeding regime and thereby, reduce feed cost to the fish farmer, whose most important production cost comes from feed. This study has concluded that, in general, *Pterocarpusmildraedi* leaf meal could be included up to 4% level in *Clarias gariepinus* diets without any negative effects on the growth. The findings in the present study recommend further investigation on the utilization of *Pterocarpusmildraedi* leaf meal in fish feed with respect to more appropriate processing methods and potent means of removing the anti-nutritional factors to enhance feed palatability and acceptability and improve nutrient utilization to produce healthy fish.

References

- Adewolu MA (2008). Potentials of potato leaf as dietary ingredient for *Tilapia zillii* fingerlings. *Pakistan Journal of Nutrition*, 7:444-449.
- Ali Turker, (2006). Effects of Feeding Frequency on Growth, Feed Consumption, and Body Composition in Juvenile Turbot (*Psetta maxima* Linnaeus, 1758) at Low Temperature. *Turkish Journal of Vet Animal Science*. **30**:251-256.
- Ali, A., Al-Asgah, NA., Al-Ogaily, SM. and Ali, S. (2003). Effect of feeding different levels of Alfalfa Meal on the growth performance and body composition of Nile Tilapia (*Oreochromis niloticus*). *Asian Fisheries Science* **16**, 59-67.
- Amisah S., Oteng M. A. and Ofori J. K. (2009). Growth performance of the African cat fish *Clarias gariepinus*, fed varying inclusion levels of *Leucaena leucocephala* leaf. *Journal Appl. Sci. Environ. Manage.* **13**:21-26.
- Anjorin, T. S., Ikkoh, P., and Okolona, S. (2010). Mineral composition of *Moringa oleifera* leaves, pods and seed from two regions in Abuja, Nigeria. *International Journal of Agriculture and Biology*, **12**, 431-434.
- Anyanwu D. C., Udedibia A. B. I., Esonu B. O. and Osuigwe D. I. (2009). Growth and nutrient utilization of heteroclaris (*Heterobranchus bidorsalis* x *Clarias gariepinus*) fed dietary levels of *Microdesmis puberula* leaf meal. *Int. J. Agric. Rural Dev.* **11**:10-13.
- Anyanwu D. C., Umeh O. I., Maduka B. C and Mbchu M. U. (2012). Nutrient utilization and growth of catfish (*Clarias gariepinus*) fed dietary levels of cassava leaf meal. *Pak. J. Nutr.* **11**(11):1037-1040.
- Bairagi, A., Sarkar Ghosh, K. S., and Ray, A. K. (2004). Evaluation of the nutritive value of *Leucaena leucocephala* leaf meal, inoculated with fish intestinal bacteria *Bacillus subtilis* and *Bacillus circulans* in formulated diets for rohu, *Labeo rohita* (Hamilton) fingerlings. *Aquaculture Research*, **35**, 436-446.
- De Silva, S. S and Anderson, T. A. (1995). *Fish Nutrition in Aquaculture*. Chapman and Hall. London. 319pp.
- Dorothy, M. S., Sudhanshu Raman, Vipin Nautiyal, Khushvir Singh, T. Yogananda and Makamguang Kamei. (2018). Use of Potential Plant Leaves as Ingredient in Fish Feed-A Review. *Int. J. Curr. Microbiol. App. Sci.* **7**(07): 112-125.

- FAO, (2014). The state of world fisheries and aquaculture: opportunities and challenges. FAO, Rome, 223 pp.
- Gabriel, U.U. O.A Akinrotimi, D.O. Bekibele, D.N.Onunkwo and P.E. Anyanwu, (2007), Locally Produced Fish Feed, Potentials for Aquaculture Development in Sub-Saharan Africa *Journal of Agricultural Research* 297: 287-295.
- Idodo-Umeh, G. (2003). Freshwater Fishes of Nigeria (Taxonomy, Ecological Notes, Diet and Utilization). Idodo-Umeh Publishers Limited, Benin City - Nigeria. pp 119 - 129.
- Mohammed, M. I., and Sharif, N. (2011). Mineral composition of some leafy vegetables consumed in Kano, Nigeria. *Nigerian Journal of Basic and Applied Science*, 19(2), 208-211.
- Olukunle O (2006). Nutritive potential sweet potato peel meal and root replacement value for maize in diets of African catfish (*Clarias gariepinus*) advanced Fry. *Journal of Food Technology* 4:289-293.
- Olurin K. B., Olojo E. A. A., Olukoya O. A., (2006). Growth of African catfish *Clarias gariepinus* fingerlings, fed different levels of cassava. *International Digital Organization for Scientific Information* 1(1): 54-56.
- Pearson, D. (1976). Chemical analysis of food, 7th edition, Churchill, London, 7-11.
- Yinka, A., Gbemiga, O. and Remi, A. (2005). Advance Commercial Catfish Farming. Oak Venture. Abeokuta, Nigeria. Pp 15-17.

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Effect of *Chlorella Vulgaris* As Feed Additive on the Growth Performance and Feed Utilization of *Clarias gariepinus* Fingerlings

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Abstract

A feeding trial was conducted to determine the effect of *Chlorella vulgaris* on the growth performance and feed utilization of *Clarias gariepinus* fingerlings in Department of Fisheries Technology, College of Agriculture Science and Technology Lafia, Nasarawa State. Fingerlings of average weight (8.85g) were placed into 5 treatments with three replicates. *Chlorella vulgaris* was cultured with chicken droppings, harvested, sun dried, and blended into powder form. Percentage inclusion of *Chlorella vulgaris* was 0% for control (TRT,1) while 0.5%, 1.0%, 1.5%, and 2% for TRT,II, TRT,III, TRT,IV and TRT,V respectively, water was supplied constantly and the water quality parameters of the source of water were monitored. Feeding was done twice a day at 3% of the fish body weight and feeding adjustment was effected as the growth of the fish appreciates weekly. Results revealed that *Clarias gariepinus* fingerlings fed TRT V (diet containing 2% *C. vulgaris*) had the highest final weight (31.3g), weight gain (22.7g) percentage weight gain (266.08%), specific growth rate (3.69g/day) and feed conversion ratio (0.05) respectively. Water quality parameters from all treatments were within the acceptable range for fish production in all the treatments, there was no mortality recorded. The inclusion of 2% *Chlorella vulgaris* is highly recommended in the formulation of feed for fast growth rate and proper food utilization of *Clarias gariepinus* fingerlings.

Keywords: *Chlorella vulgaris*, Feed additive, Growth, *Clarias gariepinus*

Introduction

Feed accounts for more than half of the variable operating costs in many aquaculture operations today NRC, (1993). Algae have been used as alternative protein source for cultured fish, particularly in tropical and subtropical regions where algae production are high with their protein, vitamins and essential fatty acids contents (El-Hindawy et al., 2006). *Chlorella* is a genus of single-cell green algae belonging to the phylum *Chlorophyta*. It is spherical in shape, about 2 to 10 µm in diameter, and is without flagella. *Chlorella* contains the green photosynthetic pigments chlorophyll-a and -b in its chloroplast. Through photosynthesis, it multiplies rapidly, requiring only carbon dioxide, water, sunlight, and a small amount of minerals to reproduce (Becker, 2007). Due to the competition, scarcity and high cost of conventional feed ingredients, which has continued to increase the cost of fish production. There is great need to exploit ways of combining them at the lowest cost possible but at the same time give the targeted output and also exploit unconventional feedstuffs in aquaculture nutrition. The study is an effort towards searching for cheap alternative source of vitamin that can reduce production cost without compromising fish quality. It is believed that *Chlorella vulgaris* has been identified to hold the potential to make contribution to fish nutrition with the possibility to reduce the total dependence on synthetic vitamin.

Materials and Methods

The experiment was conducted in the Research Farm of Department of Fisheries Technology, College of Agriculture Science and Technology Lafia, Nasarawa State, Lafia is a city located in Nasarawa State of Nigeria with the GPS coordinates of 8° 30' 21.6396" N and 8° 31' 21.6156" E. The elevation of Lafia is 204.667m above sea level, with a mean temperature of 34°C, relative humidity of 40-86% and average day light of 9-12h (NIMET, 2011). Fifteen sets of 40 litres black bowls were used for raising of fingerlings, five treatments in three (3) replicates.

Production of *Chlorella vulgaris*

Chlorella vulgaris was cultured by taking chicken droppings from teaching and research farm of Faculty of Agriculture, Nasarawa State University Keffi. Plastic bowls of 50 liters were used and the volume of water in each basin was 45 liters while pure *Chlorella vulgaris* was inoculated into the bowls containing clean water and a net was used to cover each of the plastic basin to prevent mosquito larvae from entering (Agwa et al., 2014). The chicken

dropping was fermented for 96 hours which was used to feed and sustain the algae. The fermentation aid in added nutrient to the algae and these cooperated in fast growth of the organism. The poultry dropping was prepared in a sack and introduced into a basin (bowl) containing a clean water volume of 45 liters for 96 hours to ferment, and after the fermentation, it was filtered with sieve and prepared into bottles to be ready for feeding the *Chlorella vulgaris*. The feeding of *C. vulgaris* was taken for the intervals of one day early in the morning for two weeks. After the growth, *Chlorella vulgaris* was harvested within two weeks, by the use of plankton net, sundried and prepared in powder form and blended with other ingredients for the experiment (Agwaet *et al.*, 2014).

Experimental Diets

Five practical diets were formulated based on the proximate composition of the feed ingredients. Diet 1 (control diet contained no algae), diet 2, 3, 4 and 5 contained 0.5, 1, 1.5 and 2% respectively of dried *Chlorella vulgaris*. Proximate composition of the pelleted feed for the experiment was performed (AOAC, 1990). Most of the ingredients used were obtained from Lafia market (Bone meal, groundnut meal, soybean meal, wheat flour, cassava flour, rice bran, vitamins, maize, methionine and lysine) but fishmeal of 72% CP was obtained from Gboko, Benue state. Only *Chlorella vulgaris* was produced for the purpose of this experiment.

The formulation of the feed was done as shown in table 1 below:

Table 1: Formulation of experimental diets (g/100g/Dm)

Dietary Treatments:		TRT I (Control)	TRT II	TRT III	TRT IV	TRT V
Ingredients:	Fish meal (70%)	35	35	35	35	35
	Soybean toasted	19	19	19	19	19
	Groundnut meal	15	15	15	15	15
	Wheat flour	10	10	10	10	10
	Cassava flour (63%)	7	7	7	7	7
	Lysine (HC)	2	2	2	2	2
	Maize grain	2	2	2	2	2
	Bone meal	0.5	0.5	0.5	0.5	0.5
	Methionine	2.5	2.5	2.5	2.5	2.5
	Rice bran (1-9%)	3	3	3	3	3
	Vitamins	1	1	1	1	1
Additives:	<i>Chlorella vulgaris</i>	0	0.5	1	1.5	2

Table 2: Proximate composition of Experimental Diets

Parameters	TRT I	TRT II	TRT III	TRT IV	TRT V
Moisture (%)	2.50	3.75	4.70	5.00	5.25
Crude protein (%)	36.55	37.15	37.85	38.15	38.45
Crude fibre (%)	4.50	4.95	5.20	5.63	5.88
Ether Extract (%)	15.00	15.85	17.25	19.05	20.15
Ash	15.01	20.50	22.00	22.50	22.85
NFE	26.44	17.80	13.00	9.67	7.42

NFE (Nitrogen free extract) = 100 – (MC+CP+ASH+CF+EE)

Fish and Feeding Regime

Clarias gariepinus fingerlings were used for the experiment and they were acclimatized in a concrete tank for two weeks before the experiment. Fish were randomly stocked in concrete tanks with one set of control, and four sets of experimental tanks were maintained for growth enhancement test. The fish were fed the diets at 3% body weight twice a day. The experiment was carried out for the duration of five (5) weeks. The fish were weighed with a sensitive weigh balance and data was taken weekly.

Experimental System

The experiment was conducted in nursery facility of College of Agriculture Science and Technology Lafia Nasarawa State, which consist of fifteen concrete tanks measured 0.09m x 0.57m with water depth 0.30m and water volume of 159.3 liters. Each tank supplied with aerated water from bore-hole which stored in tanks for 24 hours. The water level was maintained to a fixed level by addition of new well-aerated fresh water. In each of the tanks

were placed 20 fingerlings of *Clarias gariepinus* raised for the experiment from the hatchery. The initial average length and weight of the fish were taken after acclimatized the fish. The main source of water used was bore-hole water. The water from each tank was usually changed at least twice a week during the experiment, the physico-chemical parameters of the water were monitored (Boyd and Lichtkoppler, 1979).

Data Calculation

Weight gain = $W_f - W_i$ Where: W_f is final mean weight and W_i is initial mean weight.

$$\text{Percentage weight gain} = \frac{W_f - W_i}{W_i} \times 100$$

$$\text{Specific growth rate} = \frac{\ln W_f - \ln W_i}{\text{Time (days)}} \times 100$$

Feed intake = $W_o - W_i$ Where: W_o = the weight of feed supplied and W_i = the left over feed.

$$\text{Feed conversion ratio} = \frac{\text{Weight of fish in gram}}{\text{Wet weight gain}}$$

$$\text{Protein efficiency ratio} = \frac{\text{Wet weight gain}}{\text{Average protein fed (g/fish)}}$$

$$\text{Survival rate (\%)} = \frac{\text{No. of fish survived at the end of the experiment}}{\text{Initial number of fish stocked}} \times 100$$

Data Analysis

Statistical analysis was performed using the Analysis of variance (ANOVA) and Duncan's multiple Range Test to determine differences between treatments means at significance rate of ($P < 0.05$). The standard errors of treatment means were estimated. All statistics were carried out using Statistical Analysis program (2000) Genstat 32 edition.

Results

The result of growth performance of *Clarias gariepinus* fingerlings fed *C. vulgaris* diet is shown in Table 3. TRT I has the lowest weight gain of 12.75g while TRT V has the highest weight gain of 22.75g. TRT V has the highest Specific growth rate (3.69g/day) and while the control (TRT I) has the lowest specific growth rate (2.54g/day). Feed consumption was significantly highest 529.05g in TRT II and lowest 404.10g in TRT III respectively. Highest feed conversion ratio of 0.05 was obtained in TRTs III and V respectively while the lowest is FCR (0.02) was obtained in TRT I (Control). TRT II has the highest protein efficiency ratio (0.96) while TRT I has the lowest (0.07).

Table 3: Growth response and nutrient utilization of *Clarias gariepinus* fingerlings fed the experimental diets

Parameters	TRT I	TRT II	TRT III	TRT IV	TRT V
Initial weight (g)	8.85	8.25	8.45	8.60	8.55
Final weight (g)	21.60 ^e	24.15 ^d	27.35 ^b	26.05 ^c	31.30 ^a
Weight gain (g)	12.75 ^e	15.90 ^d	18.90 ^b	17.45 ^c	22.75 ^a
Percentage weight gain (%)	144.07 ^e	192.73 ^d	223.67 ^b	202.91 ^c	266.08 ^a
Specific growth rate	2.54 ^e	3.06 ^d	3.37 ^b	3.17 ^c	3.69 ^a
Feed intake	523.84 ^b	529.05 ^a	404.10 ^e	423.66 ^d	501.26 ^c
Feed conversion ratio	0.02 ^d	0.03 ^c	0.05 ^a	0.04 ^b	0.05 ^a
Protein efficiency ratio	0.07 ^c	0.96 ^a	0.12 ^b	0.11 ^b	0.12 ^b

Means with same superscript along the row are not significantly different ($p > 0.05$).

TRTI = Control (0.0%) inclusion of *C. vulgaris*, TRTII = Treatment with (0.5%) inclusion of *C. vulgaris*, TRTIII = Treatment with (1.0%) inclusion of *C. vulgaris*, TRTIV = Treatment with (1.5%) inclusion of *C. vulgaris*, TRTV = Treatment with (2.0%) inclusion of *C. vulgaris*

Discussion

The use of microalgae as fish feed inputs has been studied with encouraging results, Broun (1980) reported positive growth performance in fish feed diets containing algae cells. Zeinhom (2004) found that fish fed diet containing 15% algae increased significant by the digestibility coefficient of dry matter (92.5%), crude protein (87.63%), ether extract (88.45%) and energy (81.41%). Tartiel (2005) found that crude protein content of *Chlorella* species was 46.7%, the crude fat content was 14.8%, total carbohydrate content was 11.6%, ash was 17.5%, crude fiber 9.30%,

nucleic acid content (RNA 2.63% and DNA 1.72%), and vitamins group antioxidant B₆, B₁₂, E, C, B-carotene (µg/g dry weight) were found to be 0.05, 0.08, 2.25, 16.0 and 2384.0, respectively. Dawah *et al.* (2002) reported that, five amino acids (aspartic acid, serine, alanine, leucine and glycine) were collectively responsible for 50% or more of the total dry matter content of *Chlorellavulgaris*. Natural food still remains the major feed for catfish rearing so a timely supply of microalgae in sufficient quantity ensures the success of a catfish hatchery.

In this study, catfish fingerlings grew well on all experimental diets containing varying levels of inclusion of *C. vulgaris* but best in the highest concentration of *C. vulgaris* inclusion. This indicates that the formulation were sufficient at (0.5%, 1.0%, 1.5% and 2.0%) inclusion of *C. vulgaris*. This is in agreement with the studies of Alegbeleye *et al.* (2008) who observed increasing trend in weight gain with increasing level of inclusion from 0.5% level. Lasisi *et al.* (2008) also recorded similar result. The result of the study indicated that the best response of the diet in the growth of the catfish fingerling was observed in the treatment TRT V. *C. vulgaris* may play a role in improving the nutrient utilization (Agwa *et al.*, 2014). The increase in growth rate growth rate of *Clarias gariepinus* fingerlings fed diet with highest inclusion level of *C. vulgaris* is an indication the *C. vulgaris* help to improve the diet utilization of the fish.

Water quality parameters from source of water for treatment in this study were within the acceptable range for fish culture according to OATA, (2008); WHO (2010) who reported that the recommended range for the various parameters pH, temperature, total alkalinity, dissolve oxygen and carbon dioxide are 5.5-9, 15-35°C, 25-100mg/l, 5-9mg/l respectively. Since all the water quality parameters were not different from each other in all the treatment, it implies that the sources of variation of the treatments in the experiment were not influenced by water quality parameters.

Conclusion

The result from this study confirmed that *Chlorella vulgaris* is one of the cheapest plant proteins and vitamins source that can be use as feed additives in the diets of Africa catfish fingerlings. At 2% the level of inclusion, highest increase in growth and nutrient utilization of *Clarias gariepinus* fingerlings was achieved, this includes weight gain, percentage weight gain, specific growth rate and feed conversion ratio.

References

- Agwa, O.K., Neboh, H.A. and Ossai-Chidi, L.N. (2014). Cultivation of microalgal using cassava waste as a growth media. *J. Algal Biomass Utili.* 5:8-19.
- Alegbeleye, W.O., Olude, O. and Ramoni, N. (2008). Effect of feeding Colocasia (*Colocasia esculenta*) corn flour as a part of energy supplement on growth and nutrient utilization in *Clarias gariepinus* (Burchell, 1822) fingerlings. *Proceedings of the 23rd Annual Conference of FISON*.
- A.O.A.C. Association of Official Analytical Chemists. (1990). Official Methods of Analysis Association of Official Analytical Chemists. Edt., KHL rich. Arlington Virginia.
- Becker, E.W. (2007). "Micro-algae as a source of protein". *Biotechnology Advances* 25 (2): 207–10. doi:10.1016/j.biotechadv.2006.11.002. PMID 17196357.
- Broun, W. (1980). Note on the survival of algal resting cells during long-term maintenance in darkness and minimum lake bottom temperature. *Comparison of Anabaena*, (5): 677-680.
- Dawah, M. A., Ibrahim, A.N. and Eladel, H.M. (2002). Amino acids content of *Chlorella vulgaris* and *Scenedesmus bijuga* raised on domestic sewage and agricultural drainage water. 1st Scientific Conference of the Egyptian Aquaculture Society. El-Arish, North Sinai, Egypt
- El-Hindawy, M. M., Abd-Razic, M.A., Gaber, H.A. and Zenho, M.M. (2006). Effect of various level of dietary algae *Scenedesmus spp* on physiological performance and digestibility of Nile tilapia fingerlings. *1st Scientific Conference of the Egyptian Aquaculture Society. Sharm El-Sheikh – Sinai, Egypt*, pp 137-149.
- Lasisi, B.A., Ipinjolu, J.K., Hassan, W.A. and Omitoyin, B.O. (2008). Growth performance of *Clarias gariepinus* (Burchells, 1992) fingerlings fed varying levels of sweet potato peel meal as substitute for maize. *African Journal of Biotechnology* Vol. (23), pp 485-490.
- National Research Council. N.R.C. (1993). Nutrition requirements of fish. National Academy Press Washington DC., U.S.A.
- NIMET (2011). Nigerian Metrological Agency. Synoptic Office, Lafia, Nasarawa State, Nigeria
- OATA (Ornamental Aquatic Trade Association). (2008). *Water Quality Criteria-ornamental fish*. Company Limited by Guarantee and Registered in England No 2738119 Registered Office Wessex House, 40 Station Road, Westbury, Wiltshire, BA13 3JN, UK.

- Tartiel, M.B. (2005). Physiological studies on some green algae. Ph.D. thesis, Faculty of Agriculture, Cairo University. Egypt.
- WHO (2010). International Standard for Drinking Water. Guidelines for Quality, Geneva.
- Zeinhom, M.M. (2004). Nutritional and physiological studies on fish. Ph.D. Thesis. Faculty of Agriculture, Zagazig University. Egypt.

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Effect of Replacement of Soybean Meal with Cocoyam Leaves (*Colocasia esculenta*) Meal on the Growth and Haematological Profile of African Catfish (*Clarias gariepinus*)

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Abstract

The effects of replacing soybean meal with cocoyam leaf (*Colocasia esculenta*) meal on the growth and haematological indices of African catfish (*Clarias gariepinus*) juveniles were investigated in a feeding trial that lasted for 56 days. *C. esculenta* leaf meal was used as a replacement for soyabean protein fraction in a 40% crude protein (CP) diet at 0% (CYL₀) (control), 20% (CYL₂₀), 40% (CYL₄₀), 60% (CYL₆₀) and 80% (CYL₈₀). One hundred and fifty *C. gariepinus* juveniles (mean weight 31.5 ± 0.94g) were randomly distributed into glass aquaria tanks at 10fish/tank in triplicate treatments of five and were fed twice daily at 8:00-9:00hrs and 16:00-17:00hrs. The mean weight gain, specific growth rate, protein efficiency ratio and feed efficiency ratio decreased with increasing levels of *C. esculenta* leaf meal in the diets and there were significant differences (P<0.05) in the values of the parameters of fish fed the control diet (CYL₀) and treated feed (CYL₂₀ - CYL₈₀). Haematological indices showed that packed cell volume (PCV), white blood cell (WBC), differential count, Mean Corpuscular Haemoglobin Concentration (MCHC), Mean Corpuscular Haemoglobin (MCH), and Mean Corpuscular Volume (MCV) were not significantly affected. In summary, cocoyam leaves meal can replace soybean meal in the diets of African catfish but other processing methods for cocoyam leaves can be explore to reduce the antinutrients in these leaves which inhibit growth.

Keywords: *Clarias gariepinus*, *Colocasia esculenta*, Haemoglobin, antinutrients

Introduction

Fish is generally accepted as protein source in diets of average Nigerians (Agbabiaka, 2010). Nutritionally, fish is about the cheapest and direct source of protein and micro nutrients for several millions of Africans (Bene and Heck, 2005). Over the past decades aquaculture has grown in leaps and bounds in response to an increasing demand for fish as a source of protein globally (Akinrotimi *et al.*, 2007). This is because production from capture fisheries has reached its maximum potential possible, as the catch is dwindling with each passing day (Gabriel *et al.*, 2007). Feed accounts for minimum of 60% of the total cost of fish production in Africa (Jamiu and Ayinla, 2003) and a major factor that determines the viability and profitability of fish farming enterprise. As aquaculture production becomes more and more intensive in Nigeria, fish feed will be a significant factor in increasing the productivity and profitability of aquaculture (Akinrotimi *et al.*, 2007). The need to intensify the culture of the fish, so as to meet the ever increasing demand for fish has made it essential to develop suitable diets either in supplementary forms for ponds or as complete feed in tanks (Olukunle, 2006). For the purpose of nutritional and economic benefits, previous researchers have made attempts at increasing the use of nonconventional plant and animal materials to replace conventional feed ingredients like maize and fish meal in fish feed ration (Falaye, 1988; Fagbenro, 1992; Olatunde, 1996; Baruah *et al.*, 2003; Eyo, 2004). Lack of readily available nutritive fish feed ingredients have continued to be a major constraint to the survival of aquaculture in the competitive global food production system (F.A.O. 2006; Ogunji *et al.*, 2005). Conventional fish feeds are usually very expensive because the traditional feedstuffs such as maize, groundnut cake, soyabean, fish meal etc. are being competed for in livestock and human nutrition. Leaf meals of most tropical plants are available and cheap (Adugna *et al.*, 1997; Ayodeji, 2005; Olurin *et al.*, 2006; Anyanwu, 2008). Their nutritive profile together with availability and very low incidence of cost make these leaf meals seem economically attractive, viable and sustainable despite their limitations in anti-nutritional factors. Two types of crops that share the name cocoyam are *Xanthosoma sagittifolium* (Tania) and *Colocasia esculenta* (Taro) (Dotsey, 2009). Taro has been said to have the potential of being used in ruminant nutrition (Babayemi and Bankole, 2009). It has been fed to snails (Okon *et al.*, 2012); fish (Aderolu *et al.*, 2009); pigs (Agwunobi *et al.*, 2002; Ngo Huu Toan and Preston, 2010); and poultry (Abdulrashid and Agwunobi, 2009; Ologhobo and Adejumo, 2011; Adejumo and Ologhobo, 2012). This work focuses on accessing the use of taro leaves as a cheap and locally

available protein source and its potential to replace more expensive soyabean meal, in improving the nutritional and health performance of the African catfish, *Clarias gariepinus*.

Materials And Methods

Experimental fish and feeding trial

C. gariepinus juveniles were obtained from the Teaching and Research Fish Farm of Fisheries and Aquaculture Technology Department, The Federal University of Technology, Akure. Prior to the feeding trial, the fish were acclimatized for one week; the fish were randomly distributed into the glass tanks of 60cm ×40cm×40cm dimension at ten (10) fish per tank. They were then starved for 24hours prior to being placed on experimental diets. Fish were graded by size and groups of 10 fish of 31.50 ± 0.94 g per replicate and the experiment was in triplicate. Ten (10) randomly selected samples were sacrificed for proximate and mineral analysis before the commencement of the experiment. Each experimental diet was fed to five replicate groups of fish for 56days. All groups were fed at the same fixed rate (initially 5% of body weight per day) which was adjusted each week. Fish were fed by 08:00 - 09:00hrs and 16:00 - 17:00hrs, for 7 days and growth was monitored weekly by batch weighing of fish from each tank.

Preparation of Cocoyam Leaves

Fresh leaves of Cocoyam (*Colocasia esculenta*) shown in plate 1 were harvested from the Teaching and Research Fish Farm of Fisheries and Aquaculture Technology Department, The Federal University of Technology, Akure. The leaves were air-dried at 35-38°C for 5days. The dried leaves were then blended into powdered form with an Excella Blending Machine and then preserved for use in an air-tight polythene bag.



Plate 1: Taro plant (*C. esculenta*) x 80

2.3. Experimental diet and design

Five (5) isonitrogenous diets (40% crude protein) were formulated to contain cocoyam leaves at 0% (control), 20%, 40%, 60%, and 80% as replacement for soyabean protein fraction in the diet of the experimental fish as presented in Table 1. Other feed ingredients for the experiment were purchased from DOTAK feed mill in Akure, Nigeria. These ingredients include fishmeal, soybean meal, groundnut cake, yellow maize, vitamin premix, methionine, lysine, starch and fish oil. All the ingredients were milled to a uniform size, mixed and pelletized to 2mm diameter with the aid of Hobart pelletizing machine (Hobart Model 200, CA, USA) in the Laboratory of Fisheries and Aquaculture Technology Department, Federal University of Technology, Akure and then air-dried. A sample of the diet was taken for proximate analysis. The fish were sorted into 15 aquaria (representing five treatments and three replicates) each with 10 fish with a known initial mean weight. The feeding trial lasted for 56days and the fish were fed the experimental diet twice daily to apparent satiation between the hours of 08:00 - 09:00hrs and 16:00 - 17:00hrs. Each aquarium was covered with nylon mesh to prevent the fish from jumping out of the aquaria. At the beginning of the feeding trial and at 14 days intervals, all the fish from each aquarium were carefully collected, counted, and batch weighed (to the nearest gram) for 56days. Weight was measured using sensitive electronic weighing balance (NAPCO JA410) and the weight was recorded for the calculation of growth performance and nutrient utilization indices. Fish mortality were monitored and recorded in each tank throughout the period of the experiment.

Table 1: Composition of the Experimental Diets in g/100g dry matter containing varying inclusion levels of taro leaf supplementation for African catfish, *Clarias gariepinus*

Ingredients	CYL ₀ (0%)	CYL ₂₀ (20%)	CYL ₄₀ (40%)	CYL ₆₀ (60%)	CYL ₈₀ (80%)
Fish Meal (65% CP)	23.30	23.30	23.30	23.30	23.30
Ground Nut Cake (48% CP)	28.00	28.00	28.00	28.00	28.00
Soybean Meal (45% CP)	25.40	17.78	15.24	10.16	5.08
Cocoyam Leaves (30% CP)	-	11.43	15.24	22.86	30.48
Yellow maize	13.40	9.59	8.32	5.78	3.24
Fish Oil	6.00	6.00	6.00	6.00	6.00
Vitamin Premix/Mineral*	2.50	2.50	2.50	2.50	2.50
Methionine	0.40	0.40	0.40	0.40	0.40
Lysine	0.2	0.2	0.2	0.2	0.2
Binder (Starch)	0.8	0.8	0.8	0.8	0.8

Table 2: Proximate composition of the experimental diets (%DM) used in feeding African catfish, *Clarias gariepinus*.

EXPERIMENTAL DIETS					
PARAMETERS(% DM)	CYL ₀	CYL ₂₀	CYL ₄₀	CYL ₆₀	CYL ₈₀
MOISTURE	9.64	10.26	9.55	10.06	10.17
CRUDE PROTEIN	40.26	40.06	40.28	40.64	40.53
CRUDE LIPID	6.56	6.45	6.15	6.64	6.23
CRUDE FIBRE	6.56	6.26	6.36	6.13	6.36
ASH	5.58	5.43	5.19	5.24	5.49
NFE ²	31.4	31.54	32.47	31.29	31.22
AIA ³	3.26	4.44	3.00	3.13	2.40
ENERGY ⁴ (KCal/g)	417.23	415.64	417.85	419.67	414.87

Evaluation of growth performance and nutrient utilization.

Fish growth performance and nutrient utilization during the experiment was carried out as described by Fasakin *et al.*, 2000; Hepher, 1998; Becker *et al.*, 1999; and Burel *et al.*, 2000.

Fish blood collection and analysis

At the end of the feeding trial, fish from each treatment were removed from culture tanks for blood analysis according to Svobodova *et al* (2006).

Proximate analysis of cocoyam leaves, experimental fish and diets

Sample of the five experimental diets and composite sample of the fish at the beginning and end of the feeding trials were analysed for the proximate composition using AOAC, (2005) method. The proximate and phytochemical analysis of the cocoyam leaves was also carried out at the preliminary stage of the experiment. Tanin was determined as described by AOAC (2005); saponin (Hudson and El-Difrawi, 1979); phyate (Reddy *et al.*, 1982); oxalate (Abeza *et al.*, 1968).

Water quality assessment

Water quality parameters such as pH, water temperature and dissolved oxygen (DO) level were monitored and measured weekly. The pH was measured with the Search Tech pH meter, DO was measured using DO meter (MODEL YSR-550D) while temperature was measured using a mercury in glass thermometer.

Statistical analysis

Biological data resulting from the experiment was subjected to one-way analysis of variance (ANOVA), mean comparison was done using Tukey HSD Test using SPSS statistical software version 22.0. Differences were considered significant at $P < 0.05$ levels.

Results and Discussion

Growth performance and nutrient utilization by *Clarias gariepinus* juveniles fed different levels of cocoyam leaf meal.

Fish in different dietary groups actively fed on the experimental diets throughout the experiment. The result obtained for the growth response, nutrient utilization and survival parameters of fish fed cocoyam leaf diets are shown in Table 3. Fish fed diets CYL₀, CYL₂₀ and CYL₄₀ had similar ($P>0.05$) final mean weight, mean weight gain and specific growth rate, but these values for the fish fed CYL₀ were significantly higher than those of the fish fed diets CYL₆₀ and CYL₈₀. The same trend of result applies to the protein efficiency ratio (PER) and feed efficiency ratio (FER) of the fish. Feed conversion (FCR) was also the same ($P>0.05$) in fish fed diets CYL₀, CYL₂₀, CYL₄₀ and CYL₆₀, while the FCR in fish fed diet CYL₀ was statistically better than that of the fish fed diet CYL₈₀. The percentage survival in all the fish fed dietary cocoyam leaf and control was above 90 and there was no significant differences ($P>0.05$) in the percentage survival of all the fish. The increase in weight gain reported in all the treatments revealed that the fish responded positively to all the diets and that the protein contents of the experimental diets adequately enhanced growth and dietary energy supply of the fish. This observation agrees with the report of Fagbenro and Arowosoge, (1991) as well as Eyo and Olatunde, (2001). There was significant difference in mean weight gain across the treatments. The result of this experiment revealed a higher body weight gain of the fish on control diet (CYL₀) than the rest of the treatments. This followed similar trend with Anyanwu *et al.*, (2009) using *Microdesmis* leaf meal diets on hybrid catfish (*Hetrobranchus bidorsalis* x *Clarias gariepinus*). Mean Weight Gain (MWG) generally followed a continuous decreasing pattern with increasing levels (from 20% to 80%) of cocoyam leaf, thus showing an inverse relationship. The decrease in the MWG of fish at 80% treatment could be attributed to the presence of anti-nutritional factors in the leaf of cocoyam. Also, Fagbenro *et al.*, (2010) reported depressed growth in *C. gariepinus* fed raw sunflower and sesame seed meals at levels above 20% inclusion. However, it was demonstrated by Francis *et al.*, 2001 that at lower levels of inclusions, there is a physiological mechanism in fish that could compensate for the presence of anti-nutrients, hence their negative effect may not be felt, but at higher levels of inclusion, when the limit might have been overrun, then the negative effect of these anti-nutrients will be well pronounced. The control diet has the highest feed intake (61.68 ± 2.75) while diet CYL₈₀ has the lowest feed intake (51.16 ± 4.44). The feed intake which reduces with increase in the inclusion level of cocoyam leaf is in agreement with Pheng Bunta *et al.*, (2008) who reported that feed intake reduced with reduction in palatability. The specific growth rate of the fish ranged between 1.34 ± 0.12 and $1.75\pm0.08\%$ /day and there were significant ($P<0.05$) differences. Nutrients seemed to be best converted into flesh by the fish fed the 0% leaf meal dietary treatment, followed by that of the CYL₂₀, CYL₄₀, while the nutrients in fishes fed diets CYL₆₀ and CYL₈₀ were least converted. In their studies on tilapia using *alfalfa* as test feedstuff, Ali *et al.*, (2003), reported a decrease in growth performance which was said to be linearly correlated with increasing levels of *alfalfa* meal in the diet. The trend in SGR of the experimental fish might be an indication of their relative responses to the varied dietary levels of *Colocasia esculenta* leaf meal. The control diet (CYL₀) has the lowest FCR of 1.17 ± 0.07 , being the most efficient in conversion of feed to flesh. Diet CYL₈₀ has the highest FCR of 1.45 ± 0.08 . However, there is no significant difference ($P>0.05$) in the FCR of fish obtained under treatments CYL₂₀ to CYL₈₀. The SGR, PER and FCR values observed in this study were in consonance with that reported by Erfanullah and Jafri (1998), Alegbeleye *et al.*, (2001) and Ochang *et al.*, (2007). With higher FCR values, there seemed to be decrease in the SGR of the fish. The control treatment (CYL₀) generally revealed a better performance than other treatments, which runs in consonance with Anyanwu *et al.*, (2008) and (2013), who acknowledged that SGR, PER and FCR of post fingerlings fed control diet were significantly ($P<0.05$) higher than those fed on dietary levels of leaf meals.

Haematological parameters of *Clarias gariepinus* juveniles fed different levels of cocoyam leaf meal diets.

The results of haematological indices presented in Table 4 shows that haemoglobin and red blood cell concentration in fish fed CYL₀ were significantly higher than the values in fish fed other diets. Meanwhile there were no significant differences ($P>0.05$) in the PCV, white blood cell and other blood parameters measured in all the treatments. All the haematological parameters measured in this study were within the recommended physiological ranges reported for *C. gariepinus*. The result of the haemoglobin showed a decrease as the *C. esculenta* leaf meal increased in the diet. The haemoglobin range ($8.67\pm1.35 - 14.30\pm0.79\text{g}/100\text{ml}$) recorded compared well with $8.70\text{g}/100\text{ml}$ for *C. gariepinus* reported by Sowunmi, (2003). The packed cell volume (PCV) ranged between 24.33 ± 2.08 and $36.00\pm4.00\%$ and were within the range of 20 to 50% reported by Pietse *et al.*, (1981). White blood cells (WBC) and lymphocytes results recorded in this study showed no significant differences ($P>0.05$) in all the treatments. The highest value of $7.43\pm1.20 \times 10^3/\text{mm}^3$ for WBC was recorded in fish fed diet CYL₈₀ while the lowest value of $5.60\pm0.62 \times 10^3/\text{mm}^3$ was recorded for fish fed diet CYL₄₀. The value range of WBC recorded in

this study was lower than the range of 16.13×10^3 and $16.39 \times 10^3/\text{mm}^3$ reported by Sotolu and Faturoti, (2009). The lymphocyte count showed that the highest value of $66.67 \pm 6.11\%$ was recorded in fish fed the diet CYL₂₀ while the lowest value of $58.33 \pm 2.08\%$ was recorded by fish fed diet CYL₆₀. Low value of red blood cells (RBC) was observed with fish fed diet CYL₈₀ while the highest value was obtained with fish fed the control diet (CYL₀). The RBC values of $2.65 \pm 0.23 \times 10^6$ to $4.22 \times 10^6/\text{mm}^3$ recorded in this study is comparable with 2.24×10^6 to $2.49 \times 10^6/\text{mm}^3$ recorded by Sotolu and Faturoti, (2009). RBC count greater than $1.00 \times 10^6/\text{mm}^3$ is considered high and indicative of high oxygen carrying capacity of the blood, which is characteristic of fishes capable of aerial respiration and with high metabolic activity (Lenfant and Johansen, 1972). The differential count, mean corpuscular haemoglobin concentrations (MCHC), mean corpuscular haemoglobin (MCH) and mean corpuscular volume recorded in this study were not significantly different statistically. The MCHC value of 32.33 ± 0.82 to $40.17 \pm 6.16\%$ recorded in this study compared fairly well with 30.70% reported for *C. gariepinus* from Asejire dam by Adedeji and Adegbile, (2011). The MCH results revealed that the value of 29.51 ± 6.96 to $34.04 \pm 3.63\text{pg}$ obtained in this study was higher than that of 20.82 to 26.60pg reported for *Heteroclaris* fed *Carica papaya* leaf meal incorporated feed (Anyanwu *et al.*, 2011). Meanwhile, MCV range of between 85.36 ± 7.94 and $94.53 \pm 22.44\text{fl}$ recorded in this experiment compare well with 79.20 to 105.32fl reported for *Heteroclaris* (Anyanwu *et al.*, 2011).

Conclusions and Recommendations

The results of this study showed that the dietary inclusion levels of cocoyam leaf meal seems to have a seemingly measurable nutritive attributes to support growth and nutrients utilization, particularly at 20% or 40% level of inclusion in the diet of *Clarias gariepinus* fingerlings and the growth response observed at the different replacement levels indicate that it is possible to replace soybean meal in the diet of *Clarias gariepinus* juveniles with sundried cocoyam leaf meal. It also showed that these meals could be viable means of improving the cost of fish feeding as the cocoyam leaf meal is readily available at no cost to farmers compare to the soybean meal. The study also revealed that the cocoyam leaf meal has stimulatory effects on the haematological indices and blood plasma enzyme of African catfish and can be used in improving the health status of the fish. Based on the conclusion from the study the followings are recommended; Further research can be done using lower levels (<40%) of dried cocoyam leaf inclusion in fish diets. Further work should be done on the processing methods used in preparing cocoyam leaf meal before its inclusion in fish feed so as to reduce the antinutritional factor to negligible quantity that has no negative effect on the fish.

Table 3: Growth Performance and Nutrients Utilization of *Clarias gariepinus* Juveniles Fed Different Levels Cocoyam Leaf Meal

Means with similar superscripts on the same row are not significantly different ($P > 0.05$), SGR¹: Specific Growth Rate, CYL₀: Diet with 0%

		EXPERIMENTAL DIETS				
PARAMETERS		CYL ₀	CYL ₂₀	CYL ₄₀	CYL ₆₀	CYL ₈₀
Initial	Mean	31.46±0.05 ^a	31.50±0.15 ^a	31.52±0.06 ^a	31.50±0.17 ^a	31.50±0.05 ^a
Weight(g)						
Final	Mean	84.12±3.97 ^a	74.03±3.65 ^{ab}	72.50±3.12 ^{ab}	69.37±7.86 ^b	66.92±4.35 ^b
Weight(g)						
Mean	Weight	52.66±3.95 ^a	42.53±3.62 ^{ab}	40.98±3.06 ^{ab}	37.87±7.70 ^b	35.42±4.40 ^b
Gain (g)						
Mean	Feed	61.68±2.75 ^a	56.78±2.27 ^{ab}	55.43±4.27 ^{ab}	53.19±3.77 ^{ab}	51.16±4.44 ^b
Intake (g)						
% Weight Gained		167.36±12.43 ^a	135.00±11.41 ^{ab}	129.98±9.48 ^{ab}	120.15±23.77 ^b	112.48±14.14 ^b
SGR ¹ (%/day)		1.75±0.08 ^a	1.52±0.09 ^{ab}	1.49±0.07 ^{ab}	1.40±0.19 ^b	1.34±0.12 ^b
Protein Efficiency		2.13±0.12 ^a	1.87±0.09 ^{ab}	1.85±0.07 ^{ab}	1.77±0.23 ^b	1.73±0.10 ^b
Ratio						
Feed Conversion		1.17±0.07 ^b	1.34±0.06 ^{ab}	1.35±0.05 ^{ab}	1.43±0.18 ^{ab}	1.45±0.08 ^a
Ratio						
Feed Efficiency		0.85±0.05 ^a	0.75±0.03 ^{ab}	0.74±0.03 ^{ab}	0.71±0.09 ^b	0.69±0.04 ^b
Ratio						
% Survival		96.67±3.33 ^a	96.67±3.33 ^a	96.67±3.33 ^a	100.00±0.00 ^a	93.33±6.67 ^a

cocoyam leaves (Control), CYL₂₀: Diet with 20% cocoyam leaves, CYL₄₀: Diet with 40% cocoyam leaves, CYL₆₀: Diet with 60% cocoyam leaves, CYL₈₀: Diet with 80% cocoyam leaves.

Table 4: Heamatological indices of *Clarias gariepinus* juveniles fed different levels of cocoyam leaf meal.

BLOOD PARAMETERS	EXPERIMENTAL DIETS				
	CYL ₀	CYL ₂₀	CYL ₄₀	CYL ₆₀	CYL ₈₀
Hb Conc (g/100ml)	14.30±0.79 ^a	9.67±1.35 ^b	9.17±1.40 ^b	10.33±1.35 ^b	8.67±1.35 ^b
PCV (%)	36.00±4.00 ^a	29.00±5.29 ^{ab}	27.67±2.52 ^{ab}	32.00±4.58 ^{ab}	24.33±2.08 ^b
WBC (x10³/mm³)	6.60±0.80 ^a	7.03±0.80 ^a	5.60±0.62 ^a	5.60±0.92 ^a	7.43±1.20 ^a
RBC (x10⁶/mm³)	4.22±0.23 ^a	3.17±0.35 ^{bc}	3.15±0.28 ^{bc}	3.43±0.31 ^b	2.65±0.23 ^c
Neutrophil (%)	38.67±4.16 ^a	31.33±4.16 ^a	35.00±4.36 ^a	39.67±1.53 ^a	39.67±3.21 ^a
Lymphocyte (%)	58.67±3.21 ^a	66.67±6.11 ^a	63.33±3.79 ^a	58.33±2.08 ^a	58.67±4.62 ^a
Monocyte (%)	2.00±2.00 ^a	1.67±1.53 ^a	1.33±1.15 ^a	1.33±1.53 ^a	1.33±1.15 ^a
Eosinophyl (%)	0.67±0.58 ^a	0.33±0.58 ^a	0.33±0.58 ^a	0.67±0.58 ^a	0.33±0.58 ^a
MCHC (%)	40.17±6.16 ^a	33.52±2.27 ^a	33.00±2.11 ^a	32.33±0.82 ^a	36.04±8.43 ^a
MCH (pg)	34.04±3.62 ^a	30.64±4.29 ^a	29.51±6.96 ^a	30.50±6.77 ^a	32.97±6.87 ^a
MCV (fl)	85.36±7.94 ^a	92.23±18.83 ^a	88.743±15.56 ^a	94.53±22.44 ^a	91.87±3.71 ^a

References

- Abdulrashid, M. and Agwunobi, L. N. (2009). Taro cocoyam (*Colocasia esculenta*) meal as feed ingredient in poultry. *Pakistan Journal of Nutrition*. 8(5):668-673.
- Abeza, R. H., Blake, J. T. and Fisher, E. J. (1968). Oxalate determination: Analytical Problems Encountered with certain lant species. *Journal of the Association of Official Agricultural Chemists* 51:963-965
- Adedeji, O. B. and Adegbile, A. F. (2011). Comparative haematological parameters of the Bagrid catfish (*Chrysichthys nigrodigitatus*) and African catfish (*Clarias gariepinus*) from Asejire Dam Southwestern Nigeria. *Journal of Applied Sciences Research* 7(7):1042–1046.
- Adejumo, I. O. and Ologhobo, A. D. (2012). Haematological response of broiler finishers fed differently processed taro cocoyam (*Colocasia esculenta* [L.] Schott). *Agricultura Tropica Et Subtropica*. 45(3):112-116.
- Aderolu, A. Z., Lawal, M. O. and Oladipupo, M. O. (2009). Processed cocoyam tuber as carbohydrate source in the diet of juvenile African catfish (*Clarias gariepinus*). *European Journal of Scientific Research*. 35(3):453-460.
- Adugna, T., Khazaal, K. and Orskor, E. R. (1997). Nutritive evolution of some browse species. *Animal Feed Science and Technology*, 67: 181-195.
- Agbabiaka, L. A. (2010). Aquaculture and Pond Management in the Tropics. Vintage books limited, Owerri. 111p
- Agwunobi, L. N., Awukam, P. O., Cora, O. O. and Isika, M. A. (2002). Studies on the use of *Colocasia esculenta* (taro cocoyam) in the diets of weaned pigs. *Tropical Animal Health and Production*, 34:241-247.
- Akinrotimi, O. A., Gabriel, U. U., Owihonda, N. K., Onukwo, D. N., Opara, J. Y., Anyanwu, P. E. and Cliffe, P. T. (2007). Formulating an environmentally friendly fish feed for sustainable aquaculture development in Nigeria. *Agric Journal*. 2(5):606-612.
- Alegbeleye, W. O., Oresegun, A. and Ajitomi, O. O. (2001). An assessment of Jackbean (*Canavalia ensiformis*) meal as an ingredient in the diets for *Clarias gariepinus* (Buchell, 1822) fingerlings. *Fish Nutrition and Feed Technology*, ed. Eyo, A.A., FISON, pp. 92 – 97.
- Alegbeleye, W. O., Oresegun, A. O. and Omitoyin, O. (2001). Use of Bambara groundnut (*Vigna subterranean*) meal in the diets of Heteroclaris fingerlings. *Moor Journal of Agricultural Research*, 2, 54-59.
- Ali, A., Al-Asgal, N. A., Al-gaily, S. M. and Ali, S. (2003). Effect of feeding different levels of alfalfa meal on the Growth performance and body composition of Nile tilapia fingerlings. *Asian Fisheries Science Journal*, 6:59 – 69.
- Anyanwu, D. C. (2008). Effects of some tropical plants leaf meals on the performance of Heteroclaris (*H. bidorsalis* x *Clarias gariepinus*). Ph.D Thesis, Federal University of Technology, Owerri, Imo State, Nigeria, 203 pp + xvii.
- Anyanwu, D. C., Udedibie, A. B. I, Osuigwe, D. I. and Ogwo, V. O. (2011). Haematological responses of hybrid of *Heterobranchius bidorsalis* x *Clarias gariepinus* fed dietary levels of *Carica papaya* leaf meal. *World Rural Observation*, 3(1):9-12.

- Anyanwu, D. C., Udedibie, A. B. I., Osuigwe, D. I., Offor, J. I., Ukagwu, J., Onogu, B. and Nwaigwe, M. O. (2013). Performance of *Heteroclarias* (*H. bidorsalis* X *C. gariepinus*) fed 5% dietary level of leaf meals. *American Journal of Research Communication*, 2013, 1(7): 197-209} www.usa-journals.com, ISSN: 2325-4076.
- Anyanwu, D. C., Udedibie, A. B. I., Osuigwe, D. I. and Esonu, B. O. (2008). Growth and nutrient utilization of *Heteroclarias* (*H. bidorsalis* x *C. gariepinus*) fed dietary levels of *Alchornea cordifolia* leaf meal. *Journal of Agriculture and Social Research*, 8(2):112 – 118.
- Anyanwu, D. C., Udedibie, A. B. I., Esonu, B. O. and Osuigwe, D. I. (2009). Growth and nutrient utilization of heteroclarias (*Heterobranchus bidorsalis* x *Clarias gariepinus*) fed dietary levels of *Microdesmis puberula* leaf meal. *International Journal of Agriculture and Rural Development*, 11: 10- 13.
- A.O.A.C. (2005). Official methods of Analysis. Association of Official Analytical Chemists, food composition, additives natural contaminants. Adrich, R. C. 18th Edition. Washington D. C., U. S. A.
- Ayodeji, O. F. (2005). Nutrient composition and processing effects on cassava leaf (*Manihot esculenta*, Crantz) antinutrients. *Pakistan Journal of Nutrition*, 4: 37- 42.
- Babayemi, O. J. and Bankole, M. A. (2009). Nutrient value and in vitro gas production of African wild cocoyam (*Colocasia esculenta*). *African Journal of Food, Agriculture, Nutrition and Development*. 9(1):593-607.
- Baruah, K., Sahu, N. P. and Debnath, D. (2003). Dietary phytase: An ideal approach for a cost effective and low polluting aquafeed. *NAGA*, 27(3):15-19.
- Becker, H. C., Loptien, H. and Robbelen, G. (1999). Breeding: An Overview. In: *Biology of Brassica Coeno Species*, Gomez-Campo, C. (Ed.). Elsevier, Amsterdam, pp: 413-460.
- Bene, C. and Heck, S. (2005). Fisheries and the millennium development goals. Solution for Africa. *NAGA* 28: 8 – 13.
- Burel, C., Boujard, T., Tulli, F. and Kaushik, S. J. (2000). Digestibility of extruded peas, extruded lupin, and rapeseed meal in rainbow trout (*Oncorhynchus mykiss*) and turbot (*Psetta maxima*). *Aquaculture*, 188 (3-4): 285-298
- Dotsey, P. (2009). The use of cocoyam, cassava and wheat flour composite in the production of rock cakes, HND dissertation, Cape Coast Polytechnic, Cape Coast, Ghana. 1:7-40.
- Douglas, J. W. and Jane, K. W. (2010). In Schalm's Veterinary Haematology. John Wiley and Sons. Blackwell publishing Ltd. pp: 1232.
- Erfanullah, and Jafri, A. K. (1998). Growth response, feed utilization and nutrient retention in *Catla catla* (Ham.) fry fed varying levels of dietary carbohydrate. *Asian Fisheries Science*, 11:223 – 230.
- Eyo, A. A. (2004). Fundamentals of fish nutrition and diet development an overview. Pp. 1-33. In A. A. Eyo (ed). National workshop on fish feed development and feeding practices in Aquaculture NIFFR, New Bussa 15th to 19th September, 2003. 65pp.
- Eyo, A. A. and Olatunde, O. A. (2001). Protein and amino acid requirements of fish with particular reference to species cultured in Nigeria. In: *Fish Nutrition and Fish Feed Technology* (AA. Eyo, Eds.) Fisheries Society of Nigeria, Lagos, 59-74.
- Fagbenro, A. O. and Arowosoge, I. A., (1991). Replacement values of some household wastes as energy substitutes in low-cost diets for rearing catfish in southwestern Nigeria. *Bioresource Technology*, 37: 197-203
- Fagbenro, O. A. (1992). Utilization of Cocoa pud husk in low diets cost by *Clarias isheriensis*, (Syhenham). *Aquaculture*, 4:175-182.
- Fagbenro, O. A., Adeparusi, E. O. and Jimoh, W. A. (2010). Nutritional evaluation of sunflower and sesame seed meals in *Clarias gariepinus*: An assessment by growth performance and nutrient utilization. *African Journal of Agricultural Resources*, 5(22): 3096-3101.
- Falaye, A. E. (1988). Utilization of cocoa husk in the nutrition of tilapia (*Oreochromis niloticus*). Ph.D. Thesis University of Ibadan, Nigeria. 260pp
- FAO (2006). State of world aquaculture FAO Fisheries Technical paper, No. 500. Rome, 134pp.
- Fasakin, E. A., Falayi, B. A. and Eyo, A. A. (2000). Inclusion of poultry manure in the diet for Nile Tilapia (*Oreochromis niloticus*, Linnaeus). *Journal of Fisheries Technology*, 2: 51-56.
- Gabriel, U. U., Akinrotimi, A. O., Anyanwu, P. E., Bekibele, D. O. and Onunkwo, D. N. (2007). Locally produced fish feed; potential for aquaculture development in Africa. *Journal of Agriculture*, 20(10):536-540.
- Hepher, B. (1998). Nutrition of pond fishes. Cambridge: Cambridge University Press. 388p.
- Hudson, B. J. F. and El-Difrawi, E. A. (1979). The Sapogenins of the seeds of four lupins species. *Journal of Plant food*, 3:181-186
- Jamui, D. M. and Ayinla, A. O. (2003). Potential for the development of agriculture in Africa. *NAGA* 26: 9 – 13.

- Lenfant, C. and Johansen, K. (1972). Gas exchange in gill, skin and lung breathing. *Respiratory Physiology*, 14:211–218.
- Ngo Huu Toan, and Preston, T. R. (2010). Taro as a local feed resource for pigs in small scale household condition. *Livestock Research for Rural Development*:22(8). Available: <http://www.lrrd.org>.
- Ochang, S. N., Fagbenro, O. A. and Adebayo, O. T. (2007). Growth performance, body composition, haematology and product quality of the African catfish (*Clarias gariepinus*) fed diets with palm oil. *Pakistan Journal of Nutrition*, 6(5): 452 – 459.
- Ogunji, J. O., Uwadiogwu, N., Osuigwe, D. and Wirth, M. (2005). Effects of different processing methods of Pigeon pea (*Cajanus cajan*) on the haematology of African Catfish (*Clarias gariepinus*) larvae. Conference on International Agricultural Research for Development. Deutscher Tropentage, 2005 Stuttgart-Hohenheim, October 11-13, 2005.
- Okon, B., Ibon, L. A., Nsa, E. E., and Ubua, J. A. (2012). Reproductive and growth traits of parents and F1 hatchlings of *Achatina achatina* (L.) snails under mixed feeding regime with graded levels of swamp taro cocoyam (*Cyrtosperma chamissonis*) and pawpaw leaves (*Carica papaya*). *Journal of Agricultural Science*, 4(11):289-298.
- Olatunde, A. A. (1996). Effect of supplementation of soyabean diet with L and D, L. methionine on the growth of mud fish, *Clarias anguillaris*. *Nigeria Journal of Biotechnology*, 9(1):9-16.
- Ologhobo, A. D. and Adejumo, I. O. (2011). Effects of differently processed (*Colocasia esculenta* [(L.) Schott] on growth performance and carcass characteristics of broiler finishers. *International Journal of Agricultural Science*, 1(4):244-248.
- Olukunle, O. (2006). Nutritive potential of sweet potato peel meal and root replacement value for maize in diets of Africa catfish (*Clarias gariepinus*) advanced fry. *Journal of Food Technology*, 4(4):289-293.
- Olurin, K. B., Olojo, E. A. and Olukoya, O. A. (2006). Growth of African Catfish, *Clarias gariepinus* fingerlings, fed different levels of Cassava. *International Digital Organization for Scientific Information*, 1: 54 -56.
- Pheng, B., Khieu, B., Preston, T. R. and Ogle, B. (2008). Survey of taro varieties and their use in selected areas of Cambodia. *Livestock Research for Rural Development*, 20, supplement Retrieved May 25, 2010. <http://www.lrrd.org/lrrd20/supplement/bunt1.htm>
- Pheng, B., Khieu B., Preston, T. R. and Ogle, B. (2008). Effect of Taro (*Colocasia esculenta*) leaf silage as replacement for fish meal on feed intake and growth performance of crossbred pigs. *Livestock Research for Rural Development*, 20 (Suppl.)
- Pietse, J. J., Smith, G. L., van Vliet, K. J., Schoobe, H. J. and Hattingh, J. (1981). Some blood parameters of the Chinese grass carp, *Ctenopharygodon idella* (Valenciennes). *South African Journal of Zoology*, 16(2):124–126.
- Reddy, N. R., Sathe, S. K., Salunkhe, D. K. (1982). Phytate in Legumes and Cereals. *Advances in food Resources*, 28:1-92.
- Sotolu, A. O. and Faturoti, E. O. (2009). Growth performance and haematology of *Clarias gariepinus* fed varying inclusions of *Leucaena leucocephala* leaf meal. *Revista UDO Agricola*, 9(4):979-985.
- Sowunmi, A. A. (2003). Haematology of the African catfish, *Clarias gariepinus* (Burchell 1822) from Eleiyele reservoir, Ibandan, Southwest Nigeria. *The Zoologist*, 2(1):40–44.
- Svobodova, Z. D., Pravda, J. and Palackova, J. (1991). Unified Methods of Haematological Examination of Fish. Research Institute of Fish Culture and Hydrobiology, Vodnany, Czech Republic, p. 31.

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Culture of Freshwater Microalgae and Its Uses in Aquaculture

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Algae are a diverse group of aquatic photosynthetic organisms generally categorized as either macroalgae (i.e., seaweed) or microalgae (unicellular). They are primarily photoautotrophic and few species are heterotrophic in nature. It possess a number of key attributes to be useful in aquaculture. With an appropriate size for ingestion 1 to 15 µm for filter feeders; 10 to 100 µm for and readily digested. Microalgae are essential nutrient, rich source and used as for biofuel, cosmetics, pharmaceutical industry, source of human food, waste water management, environmental treatment, bio-fertilizer, and feed. Application of microalgae in aquaculture are sole component in hatchery, food additives to basic nutrients, potentials feed ingredient, and waste water treatment. The nutrients fed as live food provides protein, energy pigment, vitamins and minerals. Microalgae nutrients cultured under favorable conditions all year-round divides and the maximum density attained depend on nutrient rich in nitrogen and phosphorus, light intensity, pH, temperature, CO₂ aeration, size of culture medium, species type etc. The scarcity and increase in price of food has led to the exploitation of microalgae as source of feed ingredient. For successful cultivation of microalgae, the steps from isolation through harvesting and preservation should be followed.

Keywords: Aquaculture, Microalgae, Fish nutrition

Introduction

Algae are special group of organisms found nearly everywhere- oceans, freshwater lakes and streams, damp soil, on rocks, and in the air. Microalgae are single-celled algae or phytoplankton represents the largest groups of microorganisms. The worldwide annual production of algal biomass is estimated to be 5 million kg/year with a market value of about 330 US\$/kg. Approximately one fifth of this biomass is used to nourish the fish and shellfish that are cultivated in aquaculture hatcheries (Muller-Feuga, 2004). Microalgae must possess a number of key attributes to be useful aquaculture species. They must be of an appropriate size for ingestion, e.g., from 1 to 15 µm for filter feeders; 10 to 100 µm for grazers (Roberts and Nicholson, 1998) and readily digested. They must have rapid growth rates, be amenable to mass culture, and also be stable in culture to any fluctuations in temperature, light and nutrients as may occur in hatchery systems. Finally, they must have a good nutrient composition, including an absence of toxins that might be transferred up the food chain. The most frequently used species in aquaculture are *Chlorella*, *Tetraselmis*, *Isochrysis*, *Pavlova*, *Phaeodactylum*, *Chaetoceros*, *Nannochloropsis*, *Skeletonema* and *Thalassiosira*. In order to be used in aquaculture, a microalgal strain has to meet various criteria, such as ease of culturing, lack of toxicity, high nutritional value with correct cell size and shape and a digestible cell wall to make nutrients available (Patilet *al.*, 2007). Some Non-toxic microalgae are *Spirulina maxima*, *Chlorella vulgaris* and *Haematococcus pluvialis* while toxic microalgae are *Anabaena spidoides*, *Microcystic aeruginosa* and *Cylindrospermopsis raciborskii*. The objective of this study is to state the composition of some freshwater microalgae and its importance in aquaculture.

Importance of Microalgae

Microalgae are essential nutrient, rich source of carbohydrates, protein, enzymes and fiber (Collaet *al.*, 2007). Besides, many vitamins and minerals like vitamin A, C, B1, B2, B6, niacin, iodine, potassium, iron, magnesium and calcium are abundantly found in microalgae. Major source of food, especially in Asian countries like China, Japan and Korea. Over the last four decades, several hundred microalgae species have been tested as food, but probably less than twenty have gained widespread use in aquaculture. In the year 1999, the production of microalgae for aquaculture reached 1,000 tonnes (62% for molluscs, 21% for shrimps and 16% for fish) (Gagneux-Moreaux *et al.*, 2007). Some of the most biotechnologically relevant microalgae are the green algae (Chlorophyceae) *Chlorella vulgaris*, *Haematococcus pluvialis*, *Dunaliella salina* and the Cyanobacteria *Spirulina maxima* which are widely commercialized and used, mainly as nutritional supplements for humans and as animal feed additives. *Spirulina platensis*, a blue-green alga is gaining worldwide popularity as a food supplement, being one of the most

nutritious food known to man. It has been shown to be an excellent source of proteins (Collaet *al.*, 2007), polyunsaturated fatty acids (Sajilata, 2008), pigments, vitamins and phenolics (Ogbondaet *al.*, 2007). Another potential economic use include by-products in fruit and vegetable preservatives (Hills and Nakamura, 1976). The biomass of these algae is marketed as tablets, capsules and liquids which are used as nutritional supplement. Microalgal biomass contains three main components: proteins, carbohydrates, and lipids (oil) as shown in Table 1 (Um and Kim, 2009).

Table 1. Biomass Composition Of Various Microalgae In Terms Of Their Main Components

Strain	Protein	Carbohydrates	Lipid
<i>Anabaena cylindrica</i>	43–56	25–30	4–7
	40	2	33
<i>Botryococcusbraunii</i>	48	17	21
<i>Chlamydomonasrheinhardii</i>	57	26	2
<i>Chlorella pyrenoidosa</i>	41–58	12–17	10–22
<i>Chlorella vulgaris</i>	49	4	8
<i>Dunaliellabioculata</i>	57	32	6
<i>Dunaliellasalina</i>	29	14	11
<i>Dunaliellatertiolecta</i>	39–61	14–18	14–20
<i>Euglena gracilis</i>	28–45	25–33	22–39S
<i>Prymnesiumparvum</i>	8–18	21–52	16–40
<i>Scenedesmusdimorphus</i>	50–56	10–17	12–14
<i>Scenedesmusobliquus</i>	47	-	1.9
<i>Scenedesmusquadricauda</i>	6–20	33–64	11–21
<i>Spirogyra sp.</i>	60–71	13–16	6–7
<i>Spirulinaplatisensis</i>	42–63	8–14	4–11
<i>Synechoccus sp.</i>	63	15	11
<i>Tetraselmismaculata</i>	52	15	3

Source: Yuanjun Li(2011)

Some microalgal species are established in the skin care market, the main ones being *Arthrospira* and *Chlorella* (Stolz and Obermayer, 2005). Microalgae are employed in agriculture as biofertilizers and soil conditioners. Majority of Cyanobacteria play important roles in maintenance and build-up of soil fertility, consequently increasing rice growth and yield as a natural biofertilizer (Song *et al.*, 2005).

Application of Microalgae in Aquaculture

Several companies produce aquaculture feeds using *Chlorella* and *Spirulina*, or a mixture. Microalgae feeds are currently used mainly for the culture of larvae and juvenile shell and finfish, as well as for raising the zooplankton required for feeding of juvenile animals (Chen, 2003). The most frequently used species in aquaculture are *Chlorella*, *Tetraselmis*, *Isochrysis*, *Pavlova*, *Phaeodactylum*, *Chaetoceros*, *Nannochloropsis*, *Skeletonema* and *Thalassiosira*. Indirect means of providing the algae are through artemia, rotifers, and daphnia, which are, in turn, fed to the target larval organisms. Microalgae species *Hypnea cervicornis* and *Cryptonemia crenulata* particularly rich in protein were tested in shrimp diets (da Silva *et al.*, 2008). Nandeesh *et al.*, (2001) reported improved growth rates for Indian carp fry with increasing levels of *Spirulina platensis* in feeds. Microalgae such as *Dunaliella salina*, *Haematococcus pluvialis* and *Spirulina spp.* are also used as a source of natural pigments for the culture of prawns, salmonid fish and ornamental fish. They are used as food additive to basic nutrients and also as waste water treatment. Microalgae are used as a sole component in hatchery as food for fish larvae and early juvenile stages (especially abalone); they are live feeds for all growth stages of bivalve molluscs e.g., oysters.

Cultivation Systems of Microalgae

Natural Cultivation system: Microalgae are grown in their natural habitat e.g., Shallow bug ponds, Tanks, Circular ponds, Raceway ponds etc. This system is less expensive, have low energy input requirements and easier to maintain and clean; its disadvantages are over-heating resulting in oxygen build-up, no control over evaporation, low productivity and susceptibility to invasion of algae predators, parasites and unwanted algae.

Laboratory Cultivation: This is the use of photobioreactor (PBR) technology and green houses. This system has high productivity; lowers CO₂ losses due to out gassing, temperature can be controlled, prevents evaporation, prevents or minimizes contamination (Zenget *et al.*, 2001). Its disadvantages are cost of construction, maintenance and requires high energy to operate. Eight major environmental factors influence the productivity of spirulina: luminosity (photo-period 12/12, 4 luxes), temperature (30 °C), inoculation size, stirring speed, dissolved solids (10–60 g/litre), pH (8.5–10.5), water quality, and macro and micronutrient presence.

Steps for Microalgae Culture

Collection, identification and isolation of microalgae: Samples are collected from culture centres or research institutes and also from the wild using plankton net of 20 micrometer. Isolation is carried out in the laboratory using micromanipulation, spraying, single cell dilution and streaking.

Conditions for microalgae growth: According to Rao *et al.* (2006) investigated time required for algae to divide and attain maximum density depends on pH (6-11) which is checked twice a week, temperature (20-35°C), nutrient rich in nitrogen and phosphorus, light intensity (1,000-10,000 lux), CO₂ aeration, size of culture medium, species type and absence of microscopic, predaceous contaminants e.g. bacteria, daily determination of cells using hemacytometer, regular monitoring to avoid foaming and contamination, observation of water color to check maximum density.

Methods of harvesting microalgae: Micro screen which uses fine mesh size of 2-20 micrometer to filter microalgae from water; Flocculation uses alum at a dosage of 1g per liter to settle microalgae (Papaziet *et al.*, 2010) and froth flotation is applying air or gas bubbles then microalgae float to the surface and is skimmed off.

Preservation methods: Drum-drying is the spraying of algae slurry in a heated rotating drum at a temperature of 120°C; Spray-drying is a method of producing dry powder from slurry by rapidly drying with hot gas; Freeze-drying entails microalgae been frozen and transferred to a vacuum chamber where ice is evaporated into dry algae.

Conclusion

Scarcity and increase in price of food has led to the exploitation of microalgae as source of feed ingredient. Microalgae rich in nutrients can be cultured under favorable conditions all year round. For successful cultivation of microalgae, the steps from isolation through harvesting and preservation should be followed. With developing technologies, there are challenges faced in the cultivation of algae for feed.

References

- Chen, Y.C. (2003). Immobilized *Isochrysisgalbana* (Haptophyta) for long-term storage and applications for feed and water quality conytol in clam (*Meretrixlusoria*) cultures. *Journal of Applied Phycology*.15:439-444
- Colla, L.M.,Reinehr, C.O., Reichert, C.J., Costa, A.V (2007). Production and biomass and nutraceutical compounds by *Spirulinaplatensis* under different temperature and nitrogen regimes *Bioresources Technology*., 98, pp 1489-1493
- Da Silva, R.L. and Barbosa, J.M (2008). Seaweed meal as a protein source for the white shrimp *Lipopenaeusvannamei*.*Journal of Applied Phycology*. 21:193-197.
- Gagneux-Moreaux, S., Cosson, R.P (2006).Growth and metal uptake of microalgae produced using salt ground water from the Bay of Bourgneuf. *Aquatic Living Resources*. 19(3), pp 247-255
- Hills, C and Nakamura, H (1978).Food from Sunlight. World Hunger Research Publishing., Boulder Creek, CA.
- Muller-Feuga, A. (2004). Microalgae for aquaculture: the current global situation and future trends. In: Richmond A (ed) *Handbook of microalgal culture. kistan Journal of Biological Sciences*. 4: 1217–1220.
- Nandeesh MC, Gangadhara B, Manissery JK, Venkataraman LV (2001). Growth performance of two Indian major carps, catla (*Catlacatla*) and rohu (*Labeorohita*) fed diets containing different levels of *spirulinaplatensis*. *Bioresources Technology*.80: 117-120.
- Ogbonda, K.H. Aminigo, R.E. and Abu, G.O. (2007). Influence of temperature and pH on biomass production and protein biosynthesis in a putative *Spirulina sp.* *Bioresour. Techno.*,98: 2207–2211.
- Papazi, A., Makridis P., Divanach, P (2010). Harvesting *Chlorella minutissima* using cell coagulants .*Journal of Applied Phycology*. 22, pp349-355
- Patil V., Kallqvist T., Olsen E., Vogt G, Gislerod HR (2007). Fatty acid composition of 12 microalgae for possible use in aquaculture feed. *Aquaculture International*.15, pp1-9.
- Raoof, B., Kaushika, B.D. &Prasanna, R. 2006.Formulation of a low-cost medium for mass production of *Spirulina*.Division of Microbiology, Indian Agricultural Research Institute, New Delhi 110 012, India and the Centre for Conservation and Utilization of Blue–Green Algae, Indian Agricultural Research Institute, New Delhi, 110 012, India. <http://www.aseanbiotechnology.info/Abstract/21019148.pdf>
- Roberts RD, Kawamura T, Nicholson CM (1999). Growth and survival of postlarval abalone (*Haliotis iris*) in relation to development and diatom diet.*Journal Shellfish Resources*. 18(1): 243- 250.
- Sajilata, M.G. Singhal, R.S. and Kamat, M.Y. (2008).Fractionation of lipids and purification of α -linolenicacid (GLA) from *Spirulinaplatensis*.*Food Chem*. 109(3): 580–586.
- Song, T. Martensson, L. Eriksson, T. Zheng, W. Rasmussen, U. 2005 Biodiversity and seasonal variation of the cyanobacterial assemblage in a rice paddy field in Fujian, China. *The Federation of European Materials Societies Microbiology Ecology*, 54: 131–140.
- Stolz, P. and Obermayer, B. 2005 Manufacturing microalgae for skin care. *Cosmetics Toiletries*, 120: 99–106.
- Um, B.H. and Kim, Y.S. 2009 Review: A chance for Korea to advance algal-biodiesel technology. *Journal of Industrial and Engineering Chemistry*. 15:1-7.
- Um, BH and Kim, YS (2009). Review: a chance for Korea to advance algal-biodiesel technology. *Journal of Industrial Engineering Chemistry*.Vol 15:1-7
- Yuanjun Li, (2011). Inexpensive culturing of freshwater algae in a simulated warm environment using chicken manure medium.MscThesisChalmers University of Technology, Goteborg, Sweden.
- Zeng, W.L., Li, H.R., Cai, Z.L. &Ouyang, F. (2001).The relationship between *Spirulinaplatensis*Geitler growth and its light utilization.*Journal of Plant Resource and Environment*. 10: 7–10.

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Growth performance of *Clarias gariepinus* Fingerlings Fed Diets with Different Inclusion Levels of Black Soldier Fly (*Hermetia illucens*) Larvae meal

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Abstract

Feeding trial was conducted in 15 aquaria tanks each with a size of (1.8 x 1.3 x 0.36m³) to evaluate the growth performance of *C. gariepinus* fed diets containing black soldier fly larvae meal (*Hermetia illucens*) as an alternative protein source to fish meal. Five isonitrogenous (42% crude protein) diets were formulated at T1 - 0% , T2- 25%, T3 - 50% and T5 - 100%. Fish were feed twice daily at 5% body weight to triplicate groups of 20 fingerlings. The result of the experiment shows the best weight gains at T3(50% BSFLM) (20.33), specific growth rate, T3(50% BSFLM) (4.43) and feed conversion ratio(4.43). The temperature, dissolved oxygen and pH were not significantly different ($P < 0.05$) but there was a significant difference ($P < 0.05$) in the ammonia concentration with the treatment. From this research, 50% inclusion of Black soldier fly larvae meal can replace fish meal with less cost and more profit to farmers.

Keywords: Aquaculture, Fish nutrition, Protein, Black Soldier Fly, *Clarias gariepinus*

Introduction

The search for alternative and sustainable protein sources in fish feed has been ongoing factors such as the protein content, amino acids profile, the digestibility, palatability as well as the anti-nutritional factors must all be put into consideration when evaluating an alternative protein source. It is in this regard, we find out that insects have a great potential to be used as feed for fish since fish naturally consume insects (Rumpold and Schluter, 2013). This research focuses on the inclusion of Black soldier fly larvae meal (*H. illucens*) as an alternative to fish meal is underutilized due to the lack of knowledge of its nutritional and economical value. The crude protein content of the black soldier fly larvae meal is about 42%, fat content of 35% and ash content of 12.1% (Aniebo and Owen, 2010) and this have indicated that the black soldier fly larvae meal has the potential to be utilized as feed ingredient in the diet of fish feed in order to solve the problem of feed wastage and management. It is in this premise that the study finds its significance. The rise in price of fish feed ingredients, especially fishmeal has greatly inhibited the growth of the aquaculture industry due to high demand and limited supply. There are lots of agricultural products and also other protein sources, example the insect meal produced in Nigeria which is underused because of the lack of knowledge of their nutritional and economical value as well as proper use in fish feed. The study is therefore, to solve the problem of financial waste that may arise in embarking in fish feed production and to solve the problem of supply and demand in fish meal and fish production.

Materials and Methods

The experiment was carried out at the aquaculture unit of the Demonstration Farm, Department of Fisheries, Faculty of Agriculture, University of Port Harcourt, Choba. The African catfish (*C. gariepinus*) was used for this experiment and the fingerlings were obtained from the demonstration farm, Choba, UNIPORT. A total of 300 fingerlings was used and was completely randomized in 3 replicates of 20 fingerlings per replica for the 5 treatments – T1 (control), T2, T3, T4 and T5. The experiment was carried out for 56 days (8 weeks). The water in the experimental tanks was regularly monitored and measured weekly for the physico-chemical properties and was renewed. The following parameters were measured insitu using a multipurpose pH meter for both temperature and pH, a DO meter for dissolved oxygen and an ammonia assay kit for ammonia. Five diets were formulated according to the dietary requirement of catfish, containing 42% crude protein and 8% fat using Pearson's square method. The experimental diets were supplemented with black soldier fly larvae meal (BSFLM) at inclusion levels of 0% in the control diet, 25% in diet two, 50% in diet three, 75% in diet four and 100% in diet five, respectively. The total weight gain (TWG), relative growth rate (RGR) (%), specific growth rate (SGR) (%/day), total feed intake (TFI), feed conversion ratio (FCR), protein efficiency ratio (PER) and survival (%) were determined according to the method of Jamabo *et al.*, 2016. All parameters were measured for all the treatments and their replicates. Mortalities were recorded as they occurred.

Statistical Analysis: Data obtained was subjected to one-way analysis of variance (ANOVA). Differences between means were separated using Least Significant Difference (LSD) at a probability level of $P < 0.05$.

Results

The summary of the physico-chemical parameters of the experimental waters during the period of study is shown in Table 1. The physico-chemical parameters of the culture water recorded a significant difference between the means of the different levels of treatments. The result of growth performance of the cultured fish (*C. gariepinus*) fed with different inclusion levels of black soldier fly feed is represented on Table 2. Fingerlings fed T3 (50% BSFLM) had the best growth performance and feed utilization parameters (mean Wt gain, FCR, SGR, feed intake and survival).

Table 1: Physico-chemical parameters of the water in the Rearing Containers During Experimental Period

Parameter	T1 (0% BSFL)	T2 (25% BSFL)	T3 (50% BSFL)	T4 (75% BSFL)	T5 (100% BSFL)
Temperature	27.40 ± 0.35 ^a	27.82 ± 0.08 ^{abc}	27.86 ± 0.06 ^{abc}	28.09 ± 0.02 ^{bc}	29.30 ± 0.01 ^c
pH	6.55 ± 0.01 ^a	6.65 ± 0.01 ^b	6.78 ± 0.01 ^c	4.83 ± 0.02 ^d	3.89 ± 0.01 ^e
Ammonia	1.08 ± 0.09 ^a	0.92 ± 0.14 ^a	2.19 ± 0.09 ^b	4.93 ± 0.34 ^c	4.73 ± 0.30 ^d
Dissolved oxygen	6.37 ± 0.20 ^c	5.50 ± 0.36 ^b	5.30 ± 0.21 ^{ab}	4.08 ± 0.08 ^{ab}	3.83 ± 0.06 ^a

Values are Mean ± SE with the same superscript values are not significantly different at $p > 0.05$.

Table 2: Growth performance of *Clarias gariepinus* fingerlings Fed Diets with Different Inclusion Levels of Black Soldier Fly Larvae meal

Parameter	T1 (0% BSFLM)	T2 (25% BSFLM)	T3 (50% BSFLM)	T4 (75% BSFLM)	T5 (100% BSFLM)
Initial weight	8.14 ± 0.01 ^a	7.93 ± 0.04 ^b	8.12 ± 0.00 ^a	8.09 ± 0.00 ^a	8.12 ± 0.00 ^a
Final weight	12.71 ± 0.19 ^a	13.72 ± 0.00 ^b	20.33 ± 0.03 ^c	15.21 ± 0.00 ^d	16.07 ± 0.02 ^e
Mean weight gain	4.57 ± 0.20 ^a	5.79 ± 0.03 ^b	12.21 ± 0.03 ^c	7.12 ± 0.70 ^d	7.95 ± 0.02 ^e
Feed conversion ratio	0.62 ± 0.00 ^a	0.44 ± 0.14 ^{ab}	0.93 ± 0.14 ^b	0.57 ± 0.33 ^c	0.41 ± 0.40 ^c
Specific growth rate	3.39 ± 0.04 ^{ac}	4.07 ± 0.09 ^{ebcd}	4.43 ± 0.05 ^{db}	3.52 ± 0.37 ^c	4.37 ± 0.03 ^d
Survival rate	88.33 ± 3.67 ^a	89.5 ± 0.47 ^{ab}	92.00 ± 7.40 ^{bc}	82.2 ± 1.13 ^c	77.07 ± 3.20 ^e
Feed intake	20.12 ± 0.00 ^a	20.06 ± 0.02 ^b	17.02 ± 0.11 ^b	21.75 ± 0.33 ^c	22.23 ± 1.02 ^c
Initial length	7.53 ± 0.01 ^a	7.51 ± 0.00 ^a	7.50 ± 0.01 ^a	7.47 ± 0.04 ^a	7.51 ± 0.00 ^a
Final length	13.87 ± 0.31 ^b	13.7 ± 0.01 ^b	17.44 ± 0.00 ^a	15.84 ± 0.06 ^c	15.44 ± 0.12 ^c
Length increase	6.34 ± 0.31 ^c	6.19 ± 0.01 ^c	8.93 ± 0.02 ^b	8.37 ± 0.02 ^a	7.92 ± 0.12 ^a
Condition factor	1.38 ± 0.03 ^d	0.40 ± 0.14 ^a	0.91 ± 0.24 ^b	0.68 ± 0.00 ^{ab}	0.67 ± 0.01 ^{ab}

Values are Mean ± SE with the same superscript values are not significantly different at $p > 0.05$.

Discussion

The addition of 50% feed of BSFLM improved the mean growth performance and feed utilization by *Clarias gariepinus*. This result was in agreement with the findings of Lara- Flores *et al.* (2003), that diet supplemented feed for fish growth with yeast and microbial mixture enhanced the growth of *C.gariepinus*. Abdelhamid *et al.* (2000) and Nwanna *et al.* (2014) also showed that, growth performance and feed utilization were significantly higher in fish fed supplemented diets compared with those fed with the control diets, which was in agreement with the present observation. The poor growth of fish fed with higher level of the BSFLM may perhaps be as a result of the level which fell above the maximum requirement of the BSFLM feed for fish growth. This indicates that increasing dietary level of BSFLM up to 50% markedly increase the growth performance of *C. gariepinus* fingerlings. The FCR of the BSFLM diet was an indication of the acceptability and good conversion of the diet by the experimental fish (Banks *et al.*, 2014). Fish fed with 100% BSFLM was much cheaper compared to the treatment with 100% fish meal, this result is coherent to the information provided by Khan *et al.*, 2016 and Onsongo *et al.*, 2018.

Conclusion

Black Soldier Fly Larvae Meal (BSFLM) based diet at 50% replacement level, encouraged a higher average number of survivors, and a better feed conversion ratio than the control. Although, the best performing treatment was 50% fishmeal and 50% black soldier fly larvae meal in terms of growth performance of *C.gariepinus* fingerlings but the most cost effective feed was with 100% BSFLM inclusion rate. However, there will be a positive gain in profit with fish fed with T3 (50% BSFLM + 50% FM) as compared with 100% fishmeal which shows the high cost of fishmeal.

References

- Abdelhamid, A. M., Khakuk, E. F. M. and Seden, M. A. A. (2000). Possibility of using dried live yeast and lactosac in Nile Tilapia fingerlings diets. *Journal of Agricultural Science*, 25: 4905 – 4911.
- Aniebo, A.O. and Owen, O.J., (2010). Effects of age and method of drying on the proximate composition of housefly larvae (*Musca domestica* Linnaeus) meal (HFLM). *Pakistan. Journal on Nutrition*, 9(5): 485-487.
- Banks, I.J.; Gibson, W.T.; Cameron, M.M. (2014). Growth rates of black soldier fly larvae fed on fresh human faeces and their implication for improving sanitation. *Tropical Medicine International Health*, 19, 14–22.
- Jamabo, N. A., Yor-Oh, M. M. and Dienye, H. E. (2016). Effect of water energizer on the growth and survival of *Clariasgariepinus* (Burchell,1822) fry. *Journal of Agriculture and Veterinary Science*. 9(11):72-74.
- Khan, S; Naz, S.; Sultan, A.; Alhidary, I.A.; Abdelrahman, M.; Khan, N.; Khan, M.; Ahmad, S. (2016). Worm meal: A potential of alternative protein in poultry feed. *World's Poultry Science Journal*, 72, 93-102.
- Lara-Flores, M., Olvera-Novoa, M., Guzman-Mendez, B. and Lopez-Madrid, W. (2003). Use of Bacteria, *Streptococcus faecium* and *Lactobacillus acidophilus* as growth promoters in Nile Tilapia (*Oreochomisniloticus*). *Aquaculture*, 216:193 – 201.
- Onsongo, V.O.; Osuga,I.M.; Gachuri, C.K.; Wachira, A.M; Miano, D.M.; Tanga, C.M.; Ekesi, S.; Nakimbugwe,D.; Fiaboe, K.K.M. (2018) Insects for Income Generation Through Animal Feed; Effect of Dietary Replacement of Soybean and Fish Meal With Black Fly Meal on Broiler Growth and Economic Performance. *Journal Economic Entomology* 111, 1966-1973.
- Rumpold, B. A. and Schlüter, O.K., (2013). Potential and challenges of insects as an innovative source for food and feed production. *Innovation Food Science and Emergence Technology* 17: 1–11.

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Survey of Fish Feed Entrepreneurship and Impact in New Bussa and Surrounding Communities

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Abstract

This research investigated fish feed entrepreneurship and impact in New Bussa and surrounding communities under Borgu Local government area, Niger State. Purposive sampling technique was used to select New Bussa and Monai for the study with concentration of 19 fish feed producers as respondents. Primary data was generated with the aid of questionnaire which was descriptively analyzed. Findings from the study established strong entrepreneurship orientation, impact on profitable enterprise, job creation, and high investment in hammer machine for production of farm-made pelletized sinking fish feed for table size fish farmers within the state and others. Five types of fish feed sizes produced are 2mm, 3mm, 4mm, 6mm, and 9 mm at an average price of ₦228 per kg, produced 704.1 tonnes per month and 8449.2 metric tonnes annually. Gender role in feed entrepreneur is men dominated against women in enterprise ownership and activities requiring physical strength. Motivating factors on thriving fish feed entrepreneurship are regular supply of electricity, availability of fish feed ingredients and access to technology for feed formulation (100%) respectively, as well as high demand for feed by table size catfish fish farmers. Threatening challenges to the fish feed enterprise are extreme harsh law enforcement on clupeids supply for fish meal (89.5%), lack of knowledge to produce floating feed (76.5%), fake machine parts and shortage of technical workers (15.8%) respectively. Based on prevailing circumstances, there is need for research and training on alternative fish meal sources, standardization and packaging of product, dialogue with stakeholders on sustainable clupeid management and supply and financial intervention for capital investment.

Keywords: Pelletized feed, catfish, aquaculture, entrepreneur, Nigeria.

Introduction

In Niger State, New Bussa is a hub for aquaculture enterprises in the value chain activities which includes; research, production, processing, feed production, marketing, transportation, input sales, and logistic supply; thereby creating wealth and jobs for men, women and youths. Substantiating this fact is Ebiloma *et al.*, (2018), that New Bussa far dominates fish farming with 73% of fish farmers and 90% of the feed mills during the last decade in Niger State. National Institute for Freshwater Fisheries Research (NIFFR) introduced aquaculture in the Kainji lake basin in 1975 as an experimental pond culture, cage culture and integrated fish cum poultry in 1984, and then it grew to demonstration pond, homestead fish pond culture in 1988, adopted villages for fish culture under West Africa Agricultural Productivity Programme (WAAPP) between 2012-2016 and now a booming viable commercial aquaculture enterprise (Okomoda *et al.*, 1994, Ifejika *et al.*, 2007, Madu and Ibiyo, 2011). At early stage of aquaculture enterprise growth in 2000 around New Bussa and environ, Ifejika *et al.*, (2007) found existence of 75 ponds owned by thirty one (31) fish farmers, whereas Madu and Ibiyo (2011) reported 110 pounds in 2007. Further evidence to buttress the facts was confirmed by Ifejika *et al.*, (2013) that aquaculture was one of the leading emerging income generating activities found in the fishing communities of the Kainji lake basin. Remarkable achievement was the transformation of rural community “Monai Adopted Village” into Modern Fish Farming Cluster termed “Victory Village” by Dr. Traore of the World Bank on monitoring team visit of WAAPP project implemented by NIFFR between 2012-2016. As at now, aquaculture entrepreneurs are investing and expanding their fish farms thereby making rural and waste lands to appreciate by more than 150-250% and attracts high economic value around rural communities in New Bussa, giving rise to active eleven (11) clusters; Senior camp, NEPA/Water works, Yauna, Agric area, FGC side, Monai/Tada, Koro, Cover Dam, Faku, New Awuru, and Malale even Sabo about 20-25kilometers. Borgu Fish Farmers Cooperative Society (BFFCS) an association of fish farmers with 105 members (men and women) are the driving force. On impact, Omeje *et al.*, (2021) empirically established that fish farming in Kainji lake basin is a viable business with high return on investment of 71.81%, 51.05% and 109.27% for the men, women and youths respectively implying that to every ₦ 1 invested in table-size fish farming, about 77.38 kobo (average value) will be realized as profit *ceteris paribus*. Also, recent study reported by Olaosebikan (2021) showed that between July 2019 and February 2020, a total of 32,340 cartons of smoked fish worth an estimated

₦1,746,360,00.00 billion were transported to Onitsha from New Bussa. While investigation of 12 middlemen showed that an estimated 7,680 tons of live table size catfish worth ₦11,255,520,00.00 billion were sold from Kainji lake basin at the market rate N655/kg. These giant strides in aquaculture value chain activities made New Bussa to be recognized as the most active aquaculture zone in Niger State as described by Ebiloma *et al.*, (2018) as a “quiet revolution” in fish farming in the state.

Already in existence are perfected technologies for formulation of sinking and floating feed fish feeds using various available feed ingredients which is available in NIFFR as shown in research works of Eyo (1991, 2003, 2004), Okoye and Sule (2001), Madu and Ufodike (2003), Ibiyo, (2013), and Ibiyo *et al.*, (2018). Upsurge in commercial catfish farming prompted investment in Farm-Made pelletized fish feed production in New Bussa to meet needs of fish farmers in terms of quantity, quality, availability and access to reduce operating cost, increase profit margin, and import substitution of foreign feed to save foreign reserve. Fish feed ingredients used to produce pelletized farm-made-feed are soya bean, wheat offal, rice bran, vitamins, premix, groundnut/ palm kernel cake, salt, clupeid, millet, cowpea and bone meal. In the context of this study, Farm-Made pelletized fish feed producers, feed millers, fish feed producers are interchanged to mean the same. Like in Nigeria, three types of feed are found in New Bussa; locally (Nigeria) manufactured extruded fish feeds, local artisanal pelletized fish feeds made by small-scale feed millers or “on-farm-feed” by fish farmers, and imported extruded fish feeds. AIEP (2004) survey reported a total of 215 fish feed producers in national inventory, of which North central zone had 36 and Niger State had only one. Ogugua and Eyo (2007) argued that many larger fish farmers have invested in Farm-Made pelletized feed production, for which the quantity of production is unclear. Also, there is issue of gender-blindness on role of men, women and youth on fish feed entrepreneurship in aquaculture value chain both at national and local levels. This makes it imperative to investigate and bridge the gap existing in knowledge on gender roles, motivation and challenges of farm-made fish feed production enterprise in Borgu local government, Niger state. The broad objective is to survey on impact of fish Feed entrepreneurship in New Bussa and surrounding communities.

Derived objectives include the following:

1. ascertain the business orientation of fish feed producers
2. describe feed sizes, and quantity produced
3. Ascertain gender roles in feed production
4. identify motivating factors on fish feed enterprises

Study Area and Research Methodology

New Bussa is the headquarters of Borgu Local Government Area (LGA) in Niger State under emirate council of Borgu. Report of National Bureau of Statistics (2011) showed that Borgu LGA has a population figure of 172,835 in the 2006 national census of which women accounted for 85, 508 (49.47%). New Bussa is the only urban town in the council area with most modern infrastructures for socio-economic growth and development which includes hospitals, three higher academic institutions, fisheries research institute, post office, five financial institutions, two military bases, daily market, more public and private secondary schools, hotels, correctional home, national park for tourism and wildlife conservation, popular Kainji dam for electricity generation and for fishing among others. Activities in agricultural value chain are the mainstay of the people in crops, fishery and aquaculture, livestock, processing, as well as trading, transportation, craft and skills. Women role in fisheries particularly in capture fishery are well documented in various research works by Alamu (1991), and Ifejika *et al.*, (2009)

The research design is survey to establish enterprise status and impact of farm-made pelletized fish feed production. For this purpose, urban town of New Bussa and environs with high concentration of feed mills was purposively chosen for the study and 19 fish feed producers formed the population and as well as respondents. The instrument for data collection was semi structured questionnaire designed to extract information on business orientation, feed sizes, and quantity of feed produced, gender roles and motivating factors. Primary data was generated through face to face interview whereas collected data was analyzed with descriptive tools (frequency, percentage, mean and standard deviation) and inferential (linear regression) statistical tools and output presented in tables and charts.

Results and Discussion

Table 1 displayed variables on business orientation of fish feed producers in New Bussa. As shown, 89.5% owners of the fish feed production enterprises were men and 10.5% belong to two federal government establishments in fisheries namely NIFFR and FCFFT. It indicates that men had entrepreneurship foresight, boldness and risk taking ability to invest on-farm pelletized fish feed against their women folk in the area. On business registration, close to

half (47.4%) operate as a legal business entity whereas 52.6% are run as illegal businesses without government recognition by law. Operation of illegal fish feed production business should be discourage due to loss of revenue by evading tax, unchecked compliancy to food safety and standard by regulatory agencies, and the risk of not benefiting from government loan interventions as small and medium enterprises. In the area, investment in fish feed production created forty seven (47) jobs through hired labour (30.4%), employment (45.7%) and apprenticeship (23.2%). This justifies jobs creation through investment in aquaculture value chain like fish feed enterprise. On experience, feed producers had an average of 5years and above (5.7368 ± 5.84848) indicating maturity in business by more than half (68.4%) of respondents, followed by 21. 1% for 6-10years and above 11years (10.5%) in the enterprise. With their vast years of practical knowledge and skills, most of them will rely on experience capitalization for enterprise success. It is surprising to note that all the fish feed producers (89.5%) relied on their personal savings for investment and working capital except two government institutions (10.5%) that depend on government subvention. Probably due to lack of business registration, unsuitable loan conditions (short duration) and high interest from two micro finance banks, Bank of Agriculture and two commercial banks in the area. Also, it's interesting to find that respondents belongs to three different business platforms namely Borgu fish farmers' cooperative association (73.7%), Borgu feed mills association (52.6%) and professional fisheries bodies (10.5%). Perhaps, there is an economic and social capital benefits they derive in terms of meeting table size fish farmers for feed production, revolving loan contribution, sharing of knowledge and information among members. Also, feed producers displayed good orientation towards business transactions record keeping by 82.4%. Attitude of keeping records is expected of an entrepreneur for business performance assessment to determine financial solvency of enterprise.

Table 1: Responses on business orientation of fish feed entrepreneurs (N=19)

Enterprise ownership	Frequency	percentage	mean
Men	17	89.5	
Government	2	10.5	
Business Registration			
Yes	9	47.4	
No	10	52.6	
Multiple Response on Job Creation			
Hired labourers	14	30.4	
Employed	21	45.7	
Apprenticeship	11	23.9	
Years of experience in enterprise			
<5	13	68.4	5.7368 (5.84848)
6-10	4	21.1	
> 11	2	10.5	
Sources of business capital			
Personal savings	17	89.5	
Government subvention	2	10.5	
Membership of business platform			
Fish farmers association	14	73.7	
Borgu feed mills association	10	52.6	
Professional association	2	10.5	
Business records keeping			
Yes	16	84.2	
No	3	15.8	

Source: Field survey 2017

Information on Table 2 highlights feed sizes, machine type, and peak of production activities. As shown, respondents produce four sizes of pelletized fish feed namely 2mm and 4mm (100%) and 6mm and 9mm by 94% for table size and brood stock fish farming. As Ibiyo *et al.*, (2018) noted, feed for fingerlings are mostly imported and not locally available. Many fish farmers prefer using imported starter feeds throughout the nursery stage (1-2 months) before changing to the lower cost feeds (USAID, 2010). Probably, feed producers lack the skill to produce feed for fingerlings at fry stage. This agrees with the statement of Ogugua and Eyo (2007), Obe and Omojola,

(2015) that lack of trained personnel in areas of aquaculture nutrition, feed formulation and processing, and machine operators is second among the challenges constituting about 27 percent. On type of machine, 94% of respondents invested on dry pelletizer machine over hammer pelletizer by 6%. From their response, fish feed producers have three categories of targeted customers namely table size fish farmers (88%), personal use (88%) and for feed sellers (28%). By implication, feed producers have readymade markets for their products which are in high demand by table size fish farmers within Niger state and others states whereas only small proportion is meant for feed sellers. High demand for farm made pelletized feed among table size fish farmers' is that it helps to reduce cost of operating cost. Ifejika *et al.*, (2018) reported 73% adoption of pelletized farm-made-feed among fish farmers in Oyo state. According to Udo and Umanah, (2017), current assessment of aquafeeds used by fish farmers in Nigeria showed that fish farmers used both imported and local pelleted feeds (33.3%), and locally produced pelleted feeds (26.7%). As such, there's need for their training to acquire new knowledge and skill on how to produce small sizes pellets (< than 1mm) of feed for fingerlings to close the gap, save foreign exchange and reduce high cost of such feeds with high protein content. Furthermore, feed producers revealed active feed production all year round for fish farmers with peak periods between July-September (100%) followed by April - June (88%), which gradually decline to 66% in October-December and 50% between January-March. Peak of fish feed production coincide with peak of fingerlings supply in the lake basin during peak of raining season between July-September and March-June as found on fingerlings supply in the lake basin and probably most northern part of the country (Ifejika *et al.*, 2017). The average cost of pelleting 1kg is ₦228.15 while majority (84.2%) pellet at between ₦201- ₦250. On quantity of feed produce in a month, respondents claimed to produce a total of 704,100 kg equivalent of 704.1 tonnes of feed in a month translating to 8449.2 metric tonnes in a year.

Table 2: Description of feed sizes and type of pelletizing machine

Sizes fish feed produced (mm)			
2mm	18	94.7	
3mm	6	31.6	
4mm	19	100	
6mm	18	94.7	
9mm	4	21.1	
Types machine acquired			
Local pelletize machine	19	100	
Hammer mill machine	19	100	
Extruder pelletize machine	2	10.5	
Targeted customers			
Table size fish farmers	16	84.2	
Personal use in farm	17	89.5	
Produce for sell	6	31.6	
Peak period of fish feed production			
January-March	14	73.9	
April –June	13	68.4	
July-September	17	89.5	
October- December	15	78.9	
Price charge for pelleting per kg			
150-200	3	15.8	
201-250	16	84.2	228.15
Kg pelletized in month			
500-10,000	10	52.6	
10,001-20,000	3	15.8	
20,001above	6	31.6	

Source: Field survey (2017)

Table 4 showed the motivating factors and challenges of fish feed entrepreneurs in the area. As revealed, supply of electricity and availability of fish feed ingredients (100%) respectively were the leading motivation factors whereas access to fish feed technology (26.3%) and labour (31.6%) were the least. On challenges, respondents picked drastic law enforcement on clupeids supply (89.5%), lack of knowledge for floating feed (76.5%) as threatening issues while low issues were fake machine parts and shortage of technical workers (15.8%). Stakeholders need to dialogue on the issue of sustainable clupeid harvesting on the lake and monitoring by regulating agency which is a key primary source of protein and aroma in fish feed ingredients.

Table 4: Motivational factors and challenges of fish feed producers

Motivation factors		
Demand for feed by fish farmers	11	57.9
Availability of fish feed ingredients	19	100
Supply of electricity	19	100
Affordable labour	6	31.6
Availability of machine parts	10	67
Access to fish feed technology	5	26.3
Challenges of fish feed producers		
Scarcity of capital	9	47.9
Lack of knowledge to produce floating feed		76.5
Security issue on clupeids	17	89.5
Low electricity current	8	42.1
Harassment by local authorities	9	60.0
Price fluctuation of raw materials	7	36.8
Issues of drying and animal control	8	42.1
Pilfering of feed	8	42.1
Fake machine parts	3	15.8
Shortage of technical workers	3	15.8

Source: Field survey 2017

Presented in Table 5 is gender role in fish feed production activities is found to be low just investment in entrepreneur dominated by men. Even though, women engaged in all the activities its physical demand is responsible for low women engagement like their men counterpart. Probably, mechanization of feed production processes will make it easier for more women involvement.

Table 5: Gender Roles in fish feed production

Feed Milling activity (crushing /pelletizing)		
Men	17	89.5
women	2	10.5
Feed Drying Activity		
Man	12	63.2
women	7	36.8
Feed Packaging		
Men	14	73.7
women	5	26.3
Feed Mixing		
Men	16	84.2
Women	9	60
Feed bag sowing		
Men	13	68.4
Women	6	31.6

Source: Field survey 2017



Hammer pelletizing machine with mixed feed



Spreading of pelletized feed for sun drying, pictures Philip Ifejika

Conclusion

Evidence from the study empirically shows that research result on fish feed formulation has commercial value to support entrepreneurship on pelletized farm-made-fish feed production in aquaculture value chain in the area of study. Encouraging factors were positive entrepreneurship orientation, technology availability, regular supply of electricity and clusters of fish farmers played important role in the thriving fish feed enterprise. Current focus will be on training to improve knowledge and skill as well as stakeholders dialogue to proffer solutions on clupeid supply monitoring by state and local teams in the area.

References

- Alamu, S.O. (1991). Assessment of women contribution to fishing industry and fish marketing in Kainji Lake Basin. NIFFR Annual Report 1991.
- AIFP. (2004): Inventory of Feed Producers in Nigeria. *Aquaculture and Inland Fisheries Project*. 1-37 .
- Ebiloma, G., R. Olatunji, T. Matthias, J. Nmadu, E. Olorunsanya, K. Baba, A. Jirgi, H. Tsado, S. Liverpool-Tasie, and T. Reardon.(2018). The rapid transformation of the fish value chain in nigeria: Evidence from niger state. Feed the future innovation lab for food security policy research paper 116: Nigeria agricultural policy project, 1-16.
- Eyo, A.A. (1991): The nutritive value of traditionally prepared fish meals. In: *Proceedings of 5th FAO Expert consultation of fish Technology in Africa*. Accra, Ghana. 21-25 October 1991.
- Eyo, A.A. (2003). Fundamentals of Fish Nutrition and Diet Development. An overview. *National Workshop on Fish Feed Development and Feeding Practices in Aquaculture Organized by Fisheries Society of Nigeria (FISON) in Collaboration with National Institute of Fresh Water Fisheries Research (NIFFR) and FAO National Special Programme for Food Security (FAO-NSPFS)*. 1 - 33.
- Eyo, J.E. (2004). The Effects of Substituting Soyabean Meal for Breadfruit Meal on Diets Acceptability, Growth Response and cost of Diets fed to *Heterobranchus bidorsalis* (♂) X *Clarias gariepinus* (♀) Hybrid. *Bio-Research*. 2(2): 27 - 23.
- Ibiyo L. M. O., Kayode, R. M. O, Oresegun A., Mogaji O., Joshua, F.O. (2018). Evaluation of Clupeids and Danish fish meal based diets on the growth of African catfish, *Clarias gariepinus* fingerlings. *Archive of Food and Nutritional Science*, 2: 031-037.
- Ibiyo, L.M.O (2013). Development of cost effective fishmeal from local aquatic resources (Clupeids and Lantern fish). *Technical Report*, Project Coordinating Office, WAAPP- Nigeria, Abuja. p.1
- Ifejika, P. I, Faleke, S.A., Omeje, J.E., and Ibeun, B.A. (2018). Trend in Fish feed usage Among Aquaculture Entrepreneurs in Oyo State. *Proceedings of 33rd FISON Annual Conference*, 459-461.
- Ifejika, P.I., Ayanda, J.O. and Sule, A.M. (2007). Socio-Economic Variables Affecting Aquaculture Production Practices in Borgu L.G.A. of Niger State, Nigeria. *Journal of Agriculture and Social Research*, Vol. 7 (2): 20-29.
- Ifejika, P. I., Ibeun, B. A., and Omeje, J. E.(2017). Survey of Fingerlings Marketing for Agri-Marketing Initiative in Kainji Lake Basin, Nigeria. *Proceedings of 32nd FISON annual Conference*, 374-378.
- Ifejika, P.I., E. N. Belonowu, Y.Y. Malgwi, A.O. Odunuga and A.A. Mbah (2013). Emerging Income Generating Activities of Fisherfolk in Riverine Communities of Niger State, Nigeria. *Journal of Fisheries and Aquatic Sciences*, 8(6): 706-713.

- Madu, C.T. and Ibiyo, L.M.O. (2011). Aquaculture development and its potentials for future development in lake kainji area. In: Raji, A; A.N. Okaeme; and M.O.Ibeun (Editors). Forty Years on Lake Kainji Fisheries Research. NIFFR Publication, 198-210.
- Madu, C.T. and Ufodike, E.B.C. (2003). Growth and survival of catfish (*Clarias unguilairis*) Juvenile fed live tilapia and maggot in conventional diets. *Journal of Aquatic Sciences*. 18: 8-12.
- National Bureau of Statistics: Annual Abstract of Statistics (2011). Federal Republic of Nigeria. 52-56p.
- Nwabeze, G.O., P.I. Ifejika, A.A. Tafida, J.O. Ayanda, A.P. Erie and N.E. Belonwu, 2013. Gender and Fisheries of Lake Kainji, Nigeria: A Review. *Journal of Fisheries and Aquatic Science*, 8: 9-1.3.
- Obe, B. W. and Omojola, F. E. (2015). Assessment of Fish Feeds Used in Fish Farms in Ado-Ekiti, Nigeria and Effects on Fish Production. *Journal of Biology, Agriculture and Healthcare*. 5: 2, 181-186.
- Ogugua, N. M. and Eyo, J. E. (2007). Finfish Feed Technology in Nigeria. *Journal of Research in Bioscience*, 3:1, 23-39.
- Okomoda, J.K., Ayanda, J.O., Oploye, G.O., and Adegbiyi, A (1994). Impact assessment of the NIFFR extension demonstration of homestead fish pond culture. NIFFR annual report. 163-164.
- Okoye, F.C. and Sule, O.D., (2001). Agricultural by-products of arid zones of Nigeria and their utilization in fish feed. Fish Nutrition and fish feed technology in Nigeria. In: Eyo, A.A (eds.) *Proceedings of the fish National Symposium on Fish Nutrition and Fish Feed Technology*, NIOMR Lagos. pp. 8-13
- Okoye, F.C. and Nnaji, J.C. (2005). *Effects of substituting fish meal with grasshopper meal on growth and food utilization of the Nile Tilapia, Oreochromis niloticus fingerlings*. In: 19th Annual Conference proceedings of the Fisheries Society of Nigeria (FISON), 29 Nov - 03 Dec 2004 ,Ilorin, Nigeria, pp. 37-44.
- Olaosebikan, B. D. (2021). Aquaculture: Then and Now in Kainji Lake Basin. Presentation at the Inauguration of Fisheries Society of Nigeria, New Bussa Branch, at FCFFT, 1st September 2021.
- Omeje, J.E., Achike, A.I., Sule, A.M., Arene, C.J. (2021). Gender Roles and Economic Differentials in Aquaculture of Kainji Lake Basin, Nigeria. *Research on World Agricultural Economy*, 2:1,1-10.
- Udo, I. U., Umanah, S. I. (). Current status of the nigerian aqua feeds industry: a review. *International Journal of Innovative Studies in Aquatic Biology and Fisheries*, 3: 1, 14-22
- USAID MARKETS (2010). *Aquaculture Buyers' Guide for Nigeria*. Compiled by J.W. Miller and S. Aleem. pp 1, 11-13.

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Mineral Composition and Fatty Acid Profile of Smoked Horse Mackerel (*Trachurus murphyi*) Using an Improved Fish Smoking Kiln

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Abstract

This work assessed the quality of mineral and fatty acid profiles of imported horse mackerel (*Trachurus murphyi*) using the improved NIOMR fish smoking kiln. 20kg of frozen imported horse mackerel were obtained from Ijora frozen food market Lagos state, Nigeria. Samples of this fish were transported to the NIOMR Pilot plant for processing and commencement of chemical analysis. Results obtained showed that, the most abundant saturated fatty acid in the fish was Palmitic acid, with a value of 19.404%, while the most abundant monounsaturated fatty acid was Elaidic acid with a value of 12.63%. However, low values of polyunsaturated fatty acid were recorded in the fish species, and the most abundant polyunsaturated fatty acid is the Docosahexaenoic acid with a value of 2.297%. While the most abundant polyunsaturated fatty acid recorded is Linoleic acid (2.075), whereas the least abundant polyunsaturated fatty acid was eicosapentaenoic acid (EPA, C20:5n-3). There was significant variation ($p < 0.05$) in the level of Docosahexaenoic acid and Eicosapentaenoic acid in the fish species. The monounsaturated fatty acids (MUFA) content of horse mackerel was mainly omega-9 fatty acids except Palmitoleic acid which is an omega-7 fatty acid. It can be concluded that the horse mackerel has a good mineral and fatty acid profiling.

Key words: Smoking kiln, fatty acid, , minerals composition.

Introduction

Fish is a highly nutritious food and it is particularly valued for its protein which is of high quality compared to those of meat and egg (Ojutiku *et al.*, 2009). It contains high quality protein, amino acids and absorbable dietary minerals (Bruhiyan *et al.*, 1993). Fish is currently being used as a good tool for food therapy and source of therapeutic substances for the treatment of coronary diseases, auto-immune diseases, anemia and protein energy malnutrition (Glomset, 1986). However, Horse mackerel (*Trachurus murphyi*) is a species of jack mackerel in the family Carangidae. Its common name was derived from the legend that other smaller fish species could ride on its back over great distances. Other common names include European horse mackerel in the United State of America, Incascad, scad, and saurel. Furthermore, the application of heat to dehydrate fish does not only remove water but excess of such heat can affect the nutritional content of the dried fish. Studies have shown that smoking causes some decrease in available lysine and that the loss of lysine is proportional to the temperature and duration of smoking. Clifford, *et al.* (1980), reported a 25% loss of available lysine on the surface of hot smoked fish fillet and a 12% loss at the center. Other basic amino acids were reduced by 6.6% on the surface but remained unchanged at the center. The aim of this project is to examine the effect of different smoking method on nutritional changes of the fish species and to evaluate the mineral contents, amount of fatty acid profile present on freshly and smoked imported Horse Mackerel (*Trachurus murphyi*) because the fish is the most consumable fishes in Nigeria due to their affordability, availability and serves as a good delicacy.

Materials and Methods

Sample collection

20kg of frozen imported Horse Mackerel (*Trachurus murphyi*) were purchased from Ijora Frozen Food market (Latitude 6° 27' 59" North and Longitude 3° 22' 36" East) in Lagos State, Nigeria. The fish samples were transported to the chemistry laboratory of the Nigerian Institute for Oceanography and Marine Research (NIOMR) Lagos, where the chemical analysis was carried out.

Preparation of fish fillets and smoking process

Prior to the preparation of the fillets and smoking of fish, samples of the fish species were selected at random. 200g of the fish were filleted for the purpose of analysis. The remaining frozen blocks of fish were allowed to thaw at 4 ± 1°C. After thawing, the fish were washed, cleaned, gutted and sprinkled with salt to be smoked, loaded into the

smoking kiln and slowly cooked for about 5 hours with charcoal at 160°C chamber temperature. Smoking was done using NIOMR Improved Smoking Kiln (Plate 1). After smoking, the fire was extinguished and the fish left in the chamber overnight to avoid being burnt. The following morning, charcoal was added and smoking continued at a temperature of 160°C chamber temperature for 8 hours. After smoking and cooling, the smoked fish were packed in polythene bags, sealed and kept in paper boxes at ambient (30-33°C) temperature and transferred to NIOMR chemistry laboratory for further analysis.



Plate 1: Improved NIOMR Fish Smoking Kiln

Determination of fatty acid profile

Fat and fatty acids were extracted from the fish using Bligh and dye method as described by AOAC (2000) into ether, then methylated to fatty acid methyl esters (FAMES). FAMES were quantitatively measured by gas chromatography model 8700 (Perkin–Elmer Ltd., Buckinghamshire, England). Fitted with non-bonded biscynopropylsiloxane stationary phase, polar capillary column Rt-2560 (100m x 0.25mm) 0.2 µm film thickness (Supelco, PA, USA) and an FID. Oxygen-free nitrogen was used as a carrier gas at a flow rate of 3.5 mL/min. The initial oven temperature was 150°C at rate of 4 min which was raised to 190°C at a rate of 2 C/min and further to 220°C held for 7 min. The injector and detector temperature were set at 260°C and 270°C, respectively. A sample volume of 1.0 µL was injected. All of the quantification was done by a built-in data-handling program provided by the manufacturer of the gas chromatograph (Perkin–Elmer) as reported earlier by Talpur *et al.* (2007).

Determination of minerals content

Mineral composition after wet digestion with a mixture of sulphuric acid, nitric and perchloric acid was determined using the Atomic Absorption Spectrophotometer (AAS) (BuchScientific, USA) for calcium, magnesium, iron, sodium, potassium and phosphorus profiling as described by Njinkoue *et al.* (2016). The concentration of mineral elements was determined using Flame Atomic Absorption Spectrophotometer (AAS) and calculated in ppm (ug/g dry weight).

Statistical analysis

Data obtained were subjected to descriptive and inferential statistics (ANOVA) using SPSS (version 17 incorporation, Chicago, Illinois, USA). Means of samples were separated using Duncan Multiple range Test.

Results

Mineral contents

The results of the mineral contents of the fish species are shown in Table 1.

Table 1: Mineral composition of Horse mackerel

Mineral parameters	Fresh sample	NIOMR Kiln smoked
Calcium (ppm)	2.10	292.10
Magnesium (ppm)	18.80	120.85
Potassium (ppm)	13.62	205.40
Iron (ppm)	3.40	21.81
Sodium (ppm)	113.42	310.11
Phosphorus (ppm)	6.36	501.52

Fatty acid profiled of horse mackerel

The fatty acid composition (% of total fatty acid) of the fish species is summarized in Table 2.

Table 2.: Fatty Acid (SFA) Composition of Smoked Horse mackerel using the NIOMR improved Smoking Kiln.

Fatty acid	Carbon atoms	Fatty acid class	% sample A
Caproic acid ME	8:0	SFA	ND
Capric acid ME	10:0	SFA	ND
Lauric acid ME	12:0	SFA	ND
Myristic acid ME	14:0	SFA	7.22
Pentadecanoic acid ME	15:0	SFA	0.55
Palmitic acid ME	16:0	SFA	19.40
Heptadecanoic acid ME	17:0	SFA	1.31
Stearic acid ME	18:0	SFA	5.45
Arachidic acid ME	20:0	SFA	1.13
Behenic acid ME	22:0	SFA	15.83
Lignoceric acid ME	24:0	SFA	ND
Total SFA			50.89

Sample A: Horse mackerel, ND=Not detected, SFA=Saturated fatty acid.

Table 2.2 : Fatty Acid (MUFA) Composition of Smoked Horse mackerel using the NIOMR improved Smoking Kiln.

Fatty acid	Carbon atoms	Fatty acid class	% sample A
Myristoleic acid ME	14:1	MUFA	ND
Cis-10-pentadecanoic acid ME	15:1	MUFA	ND
Palmitoleic acid ME	16:1	MUFA	5.348
Cis-10-Heptadecanoic acid ME	17:1	MUFA	ND
Elaidic acid ME	18:1 Cis	MUFA	12.63
Cis-11-Eicosenoic acid ME	20: 1 n9	MUFA	2.55
Erucic acid ME	22:1	MUFA	5.85
Nervonic or Cis-15-tetracosenoic acid ME	24:1	MUFA	15.66
Total MUFA			42.04

Sample A: Horse mackerel, ND=Not detected, MUFA=Monounsaturated fatty acid.

Table 2.: Fatty Acid (PUFA) Composition of Smoked Horse mackerel using the NIOMR improved Smoking Kiln

Fatty acid	Carbon atoms	Fatty acid class	% sample A
Linoleic acid ME	18:2 trans	PUFA	2.08
Linolelaidic acid ME	18:2 Cis	PUFA	1.72
Linolenic acid ME	18:3 n3	PUFA	0.69
Cis-11-14-Eicosenoic acid ME	20:2	PUFA	ND
Arachidonic acid ME	20:4 n6	PUFA	ND
Cis-5,8,11,14,17-Eicosapentaenoic acid ME	20:5	PUFA	ND
Cis-4,7,10,13,16,19-Docosa hexanoic acid ME	22:6	PUFA	2.29
Total PUFA			6.78

Sample A: Horse mackerel, ND=Not detected, PUFA=Polyunsaturated fatty acid.

Discussion

The mineral contents of horse mackerel significantly varied ($p < 0.05$). The calcium content of NIOMR kiln smoked horse mackerel recorded the highest value of 292ppm, while the least value of calcium content was recorded in fresh horse mackerel with 2.10ppm. NIOMR kiln smoked horse mackerel recorded the highest value of magnesium with 120.85ppm. The least value of magnesium content was observed in fresh horse mackerel with 18.8ppm. The highest value of potassium was recorded in NIOMR kiln smoked horse mackerel with 205.4ppm, the least value of potassium content was observed in fresh horse mackerel (13.2ppm). However, highest value of sodium content was recorded in NIOMR kiln smoked horse mackerel with 310.11ppm, the least value of sodium content was observed in fresh horse mackerel (113.42ppm). Phosphorus content recorded the least value in fresh horse mackerel (6.36ppm). Iron content value was 21.81ppm in NIOMR kiln smoked horse mackerel while 3.40ppm was recorded for the fresh sample. The results of mineral content in this study is in line with the findings of Adewoye *et al.* (2003) who reported that variations exist in mineral composition of fish.

The fish species examined contained appreciable concentrations of calcium, sodium, magnesium, potassium, phosphorus and iron suggesting that these fishes could serve as good sources of minerals. Calcium helps for growth and maintenance of bones, teeth and muscles in human (Turan *et al.*, 2003). Normal extracellular calcium concentrations are necessary for blood coagulation and for the integrity, intracellular cement substances (Okaka and Okaka, 2001). Sodium is an activator of transport ATP-ases in animals and also in plants possibly (Adeyeye and Adamu, 2005). While, magnesium ions regulate over 300 biochemical reactions in the body through their role as enzyme co-factors (Dana *et al.*, 1985; Fabiola and Martha, 2012).

The saturated fatty acid (SFA) contents obtained from this study for NIOMR smoked horse mackerel, was 50.886%, while the monounsaturated fatty acid was 42.04%. The polyunsaturated fatty acid contents obtained from the NIOMR smoked horse mackerel was 6.779%. Results for fatty acid profile from this study was similar to that reported by Kolade (2015) who studied the fatty acid profile of Horse mackerel (*Trachurus murphyi*) from Agbalata market in Badagry, Lagos state Nigeria.

Palmitic acid (C16:0) was the most abundant saturated fatty acid contents obtained from the NIOMR smoked horse mackerel with a value of 19.404%, followed by myristic acid (C14:0) with 7.216%. The least abundant saturated fatty acid recorded was Pentadecanoic acid and lignoceric acid in horse mackerel. Palmitic acid and myristic acid are healthy fat and have been reported to help in weight loss, reduce the risk of heart disease and decrease inflammation human (WHO, 2007; Fabiola and Martha, 2012). Other least occurring fatty acids amongst the saturated fatty acid (SFA) was found to be Pentadecanoic acid (0.55 %), this could be as a results of the fishes been grown in captivity as reported by Lenas *et al.* (2011) in his finding that fish grown under captivity usually have reduction in Pentadecanoic acid and Behenic acid due to land based oil used during culturing. Several authors have also reported palmitic acid (C16:0) as the most abundant saturated fatty acid in different fish species (Alasalvar *et al.*, 2002; Sengor *et al.*, 2003; De Silva *et al.*, 2004; Rossano *et al.*, 2005; Bayir *et al.*, 2006; Senso *et al.*, 2007) which are similar to the findings of this study. Level of palmitic acid was found to be lower in horse mackerel (19.4%) presumably due to their physiology and environmental factors and this is in agreement with the report of Saglik and Imre (2001) who studied N-3-Fatty acids in some fish species from Turkey.

Tetracosenoic acid (C24:1) was identified most abundant monounsaturated fatty acid (15.66%) in the smoked horse mackerel fish. This was followed by Nervonic acid (C22:1) with a value of 5.85%, Palmitoleic acid was (5.348%) while, eicosenoic acid value was 2.551. Monounsaturated fatty acid such as tetracosenic acid, Nervonic acid Palmitoleic acid have been reported to play a vital role in human such as reduction of high blood pressure and anemia in women, prevention of certain birth defects, decrease risk of cardiovascular disease by decreasing homocysteine, decrease risk of cancer by improving DNA/RNA repair and gene expression (WHO, 2007) confirming the fish species studied to be a good source of fatty acid diet. The monounsaturated fatty acids (MUFA) content of horse mackerel was mainly omega-9 fatty acids except Palmitoleic acid which is an omega-7 fatty acid. The higher content of tetracosenoic acid could be directly related to fatty acid contents used in their feed formulation (Lenas *et al.*, 2011).

The most abundant polyunsaturated fatty acid recorded is Linoleic acid (2.075) in horse mackerel. While the least abundant polyunsaturated fatty acid was eicosapentaenoic acid (EPA, C20:5n-3). There was significant variation ($p < 0.05$) in the level of Docosahexaenoic acid and Eicosapentaenoic acid in the smoked fish samples. Varying level of Eicosapentaenoic acid and Docosahexaenoic acid have been reported for different horse mackerel species caught in different seas (Bandarra *et al.*, 2001; Celik, 2008; Nazeer and Kumar, 2012).

Different health organizations recommend varying amounts of daily n-3 polyunsaturated fatty acid, Eicosapentaenoic acid and Docosahexaenoic acid intake in a range of 0.2g – 0.45g and 0.5g – 1.0g respectively, depending on the amount of some other fatty acids such as linoleic, linolenic and arachidonic acids Gogus and Smith, 2010; Candela *et al.*, 2011. These values falls within the recommend values, affirming that the fish could serve as a good source of n-3 polyunsaturated fatty acid required for prevention of obesity, anti-inflammatory effects in cancer and metabolic disorders (WHO, 2007; FAO, 2016) It was also suggested that 4550mg EPA + DHA should satisfy the weekly requirement of an adult on a 200-kcal diet (Simopoulos, 2003). However, epidemiological/observational studies as well as past clinical trials have demonstrated that higher values of n-3 Polyunsaturated fatty acid, Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA) are usually needed for the treatment and/or preventive effect of various illness such as cardiovascular and neurological disorders (Kris-Etherton *et al.*, 2003; Candela *et al.*, 2011). Lee and Hiramatsu (2011) summarized the recommended values set by various health organizations for health benefits including primary and secondary prevention of coronary heart diseases. According to the suggested values of EPA and DHA, healthy adults should eat 0.5g daily while patients with coronary heart disease should consume 1.0g. Therefore, from this study, eating the fish species could help to prevent coronary heart disease and neurological disorders.

Conclusion

The results obtained in this study has provided scientific information and detailed knowledge of the mineral and fatty acid profile of this commercial fish species. The results showed that the fish species had high quality levels of mineral and fatty acids. Overall, *Trachurus murphyi* smoked with NIOMR smoking kiln appears to be suitable as diet for humans due to its relatively high nutrient components and the ratio of polyunsaturated and saturated fatty acid. The fatty acid components of horse mackerel (*Trachurus murphyi*) used in this study suggest that it is a desirable item in the human diet, especially for the levels of DHA and EPA found are good for the maintenance of human health.

References

- Abd Rahman, S., Thiess, S. H., Osman, H. and Daud, N. M. (1995). Fatty acid composition of some Malaysian fresh water fish. *Journal of Food Chemistry*, 54: 45–49.
- Ackman, R.G. (1988). Concerns for Utilization of Marine Lipids and oils. *Journal of Food Technology*, 42:151-155.
- Adewoye, S.O., Fawole, O.O. and Omotosho, J.S. (2003). Concentrations of selected elements in some freshwater fishes in Nigeria. *Science Focus*, 4: 106-108.
- CRC Press, United State (2008), Taylor & Francis Group, sound parkway NW, suite 300. FL 33487-2742, Standard book number – 13:973-1-4200-1581-2 (e book PDF)
- Bayir, A., Haliloglu, H.I., Sirkecioglu, A.N. and Aras, N.M. (2006). Fatty acid Composition of Some Selected Marine Fish Species Living Turkish Waters. *Journal of Science and Food Agriculture*, 86:163-168.
- Clifford, M. N., Tang, S. L. And Eyo, A. A. (1980). The Development of Analytical Methods for Investigating Chemical changes during Fish Smoking. Pages 286 – 290. n: Advances in Fish Science and Technology. Fishing News Books Limited, Farnha

- Dana, J.D., Hurlbut, C.S. and Klein, C. (1985). Manual of Mineralogy (2nd Edn.). John Wiley and Sons Inc. New York, pp: 115-121.
- Dewan, R., Gupta, R., Gupta, A. and Uma, K. (2003). Effect of supplementation of diet with polyunsaturated fatty acids on *Helicobacter pylori* eradication and duodenal ulcer healing. *American Journal of Gastroenterology*, 98: 54-63.
- Duran, A., Tuzen, M. and Soylak, M. (2010). Trace element concentrations of some pet foods commercially available in Turkey. *Food Chem. Toxicol.*, 48:2833–2837.
- FAO, (2005). Post-harvest changes in fish. In: FAO Fisheries and Aquaculture Department, Food and Agriculture Organization, Rome, Italy. <http://www.fao.org/fishery/topic/12320/en>.
- FAO, (2016). Nutritional Elements of Fish, FAO-Fisheries and Aquaculture Department. (<http://www.fao.org/fishery/topic/1239/en.htm>).
- FAO. (2017). Food and Agriculture organization of the United Nations Rome, 2009. The state of food and agriculture. Trends in global food security pp.104.
- Froese, R. and Pauly, D. (2006). The use of modern relational databases for identification of fish larvae of "*Trachurus trachurus*" in *Fish Base*. *J. Appl. Ichthyol.* 6(1):37-45
- Fawole, O.O., Hogstrand, C. and Wood, C.M. (1996). The physiology and toxicology of zinc in fish, In E. W. Taylor (Ed.), *Toxicology of Aquatic Pollution*, Cambridge: University Press, pp. 61-84.
- Lecerf A, G Woodward, MO Gessner, PS Giller, V Gulis, S Hladysz, (2007). [Continental-scale effects of nutrient pollution on stream ecosystem functioning](#). *Science* 336 (6087), 1438-1440
- Lee, A.H. and Hiramatsu, N. (2011). Role of n-3 series polyunsaturated fatty acids in cardiovascular disease prevention. *J. Nutr. Diet. Suppl.*, 3: 93–100.
- Lenas, D., Chatziantoniou, S., Nathanailides, C. and Triantafillou, D. (2011). Comparison of wild and farmed Horse mackerel and Blue whiting lipid quality. 11th International. Journal of Aquatic Food Product Technology. 10.1080/10498850.2015.1056398.
- Mat Jais, A. M., McCulloh, R. and Croft, K. (1994). Fatty acid and amino acid composition in haruan as a potential role in wound healing. *General Pharmacology*, 25:947–950.
- Osibona, A.O. (2005). Comparative study of proximate composition, amino acids, fatty acids and aspects of the biology of some economic fish species in Lagos State, Nigeria. Ph.D. Thesis. pp. 218.
- Patir, B. and Inanli, A.G. (2005). Microbiological quality and TMA-N levels of fresh Horse mackerel (*Trachurus mediterraneus*, S. 1868) marketed in Elazig. *Journal of Science and Engineering*, 10(2): 260-369.
- [Raatz S.K¹](#), [Silverstein J.T](#), [Jahns L](#), [Picklo M.J](#). (2013). Issues of fish consumption for cardiovascular disease risk reduction. *Nutrients*. Mar 28;5(4):1081-97. doi: 10.3390/nu5041081.
- Turan, M., Kordali, S., Zengin, H., Dursun, A. and Sezen, Y. (2003). Macro and micro-mineral content of some wild edible leaves consumed in Eastern Anatolia. *Acta Agric. Scand. Sect. B, Plant Soil Science*, 53: 129-137.
- USDA Food Safety Information. (2013). Freezing and Food Safety, http://www.fsis.usda.gov/wps/wcm/connect/cce745c9-0fc9-4ce6-a50c-84363e5b5a48/Freezing_and_Food_Safety.pdf?MOD=AJPERES. Accessed 10-12-13.
- Venugopal, (20009). Marine Proteins and Peptides: Biological Activities and Applications. John Wiley & Sons, pages 816 - 817.
- Ward, A. R. (1995). Fish Smoking in the tropics. A review. *Journal of Tropical Science* 35:103-112.
- WHO, (2007). Protein and amino acid requirements in human nutrition: report of a joint HO/FAO/UNU expert consultation, WHO Technical Report Series World Health Organization, Geneva, Switzerland. pp.123

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Efficiency of lemon grass (*Cymbopogon citratus*) and orange peels (*Citrus sinensis*) powder on preservation qualities of smoked *Clarias gariepinus* and *Mormyrus rume*

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Abstract

Preservation and processing is an important part of commercial fisheries; the fishes remain fresh for long time, with minimum flavour loss, taste, odour, nutritive value and the digestibility of their flesh. An experiment was conducted to determine the efficiency of lemon grass (*Cymbopogon citratus*) and orange peels (*Citrus sinensis*) powdered on preservation qualities of smoked *Clarias gariepinus* and *Mormyrus rume*. Four treatment; 0% as control (Trt1), 100% lemon grass powder (Trt2), 100% orange peel powdered (Trt3) and combination of both 50+50% lemon grass and orange peels powder (Trt4) tied within muslin cloth were used to preserve 1kg of smoked fish for eight weeks using 10 grams of bio preservation. Activities like, proximate composition, peroxide value, and sensory evaluation before and after preserving were carried out. The highest protein value 68.12 was recorded for *Clarias gariepinus* (Trt1) and *M. rume* also having a value of 75.0 respectively. Lipid content was highest in *C. gariepinus* Trt1 (12.0) and lower in Trt4 (5.0) while in *M. rume* highest value in 0%=10.50 and lower 6.5. The weight loss in *C. gariepinus* was high in Trt1 (16.12) as with *M. rume* (34.4) than other that having bio preservative. In both fish species, the number of insect infestation found in preserved was low with Trt4 for *M. rume* showing no signs of infestation. The highest peroxide value Trt1 (28.2) was observed in *C. gariepinus* and least in Trt4 (22.6) while, *M. rume* recorded the least value in Trt4 (12.2). Reducing production loss will be a great success to sustainable aquaculture and the use of lemongrass and orange peel powder as bio preservation have shown a high tendency in the reduction of insect infestation and lower peroxide values.

Keywords: Nutritive value, Sensory evaluation, Smoked fish, Peroxide values, Preservation

Introduction

The processing of a fish species inevitably entails a storage period for the finished product prior to marketing and consumption. Since fish are composed of perishable nutrients, storage period should be kept to a minimum with adequate storage conditions provided so as to prevent deteriorative changes occurring through oxidative damage and/or microbial, insect or rodent infestation. Smoking of fish is one of the most ancient processing technologies. It has been for centuries used for preservation, and is still widely used for this purpose among several communities in the third world where up to 70% of the catch is smoked for preservation. However, in industrialized countries, smoking of fish is done for enhancement of flavour and texture; often producing value added products whose preservation is achieved (Idris *et al.*, 2010). Heat generated as a result of smoking dehydrate, inhibits bacterial growth, retard enzymatic actions, add aroma, taste and colour on processed fish, but its quality can deteriorate during storage due to lipid-oxidation and microbial growth. Fish can be smoked whole, cleaned, split or filleted, depending on local preferences and the desired final product. An important fact is that the greater the surface area of the fish, the greater the amount of smoke particles which can be absorbed. Traditional smoked fish, though popular, suffer from some inherent problems, including un-even cooking of the product, scorching and burning due to direct heating, bitterness, unattractive appearance, rancidity development, limited shelf-life and insect infestation (Idris *et al.*, 2010). Rancidity development may also affect the nutritional value, keeping quality, as well as consumer acceptance. Oikeh *et al.* (2013) reported fungal spoilage, lipid oxidation (production of off-flavours) and poor storage stability of smoked-dried fish as some of the problems of the fish industry in Nigeria. In order to eliminate much of the short comings associated with the use of synthetic insecticides and provide an effective storage and preservation techniques, there have been in recent years an increasing and concerted effort at developing plant base toxicants that are environmentally friendly. In the fish processing industry, replacement of synthetic antioxidants by plant is being widely encouraged by researchers and processors. Quality and shelf life of fish and fish products are often enhanced by using various food additives during handling, processing and storage. Due to potential health hazards synthetic additives are being replaced by their natural counter parts.

African catfish (*Clarias gariepinus*) is one of the most important fish species currently being cultured both inside and outside its natural range of tropical and subtropical environments (Adewolu *et al.*, 2008). Positive attributes such as resistance to diseases, high fecundity, and ease of larval production in captivity make it of commercial importance in aquaculture. Mormyrus or elephant snout fishes (*Mormyrus rume*) are freshwater tropical fishes. Twenty six species of the family Mormyridae occur all over Nigeria (Ada, 2018). They are curious looking fish, highly variable in the shape of their head and the extent of their unpaired fin (Fawole, 2002). They are reported as bottom dwellers feeding on insect larvae (Olaosebikan and Raji, 2013); *M. rume* are readily available, tasty with soft bones and preferred by the common population. They account for a significant proportion of the total fish landing in most fresh fish landing sites in Nigeria (Reed *et al.*, 1967; Ada, 2018).

Cymbopogon, better known as lemongrass, is a genus of Asian, African, Australian, and tropical island plants in the grass family. Common names include lemon grass, barbed wire grass, silky heads, citronella grass, fever grass, cochineal grass etc. The leaves and the oil (citral) are used to make medicine due to its antibacterial activities. It is commonly used in teas in Africa and Latin America; soups, and curries especially in Asian cuisine and as medicinal herbs in India; it is used as a natural pesticide (Hussein *et al.*, 2015) in farms (tomatoes and broccoli). The oil is used in aromatherapy, repel insects and as attractant for honey bees (Shah *et al.*, 2011; Tounkos, 2019).

Orange is one of the most popular fruits in Nigeria but very few consume the peel which is arguably the healthiest part of the fruit. The orange peels (a by-product from orange juice industry) are rich in nutrient and contain many phytochemicals (phenolic compounds, flavonoids (Skrede and Wrolsted, 2002) like flavonones and polymethoxylated flavones. Orange peel according contains a higher antioxidative activity than the seeds (Tripoli *et al.* (2007) and they can be used as carminative insect repellent (Kanaze *et al.*, 2009); they act as an antibacterial agent against *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Klebsiella pneumoniae* (Dubey *et al.*, 2011; Edogbanya *et al.*, 2019).

Smoked *Clarias gariepinus* and *Mormyrus rume* are commercially important fish species in Nigeria with a high consumer acceptability. Food preservatives are used to kill or inhibit the growth of micro-organisms and in the process increasing the shelf-life of food. However, the increase in the number of antibiotic resistance pathogen has led to the search for an alternative drug that is regarded as safe. The exploration of a safe, effective and acceptable natural preservatives on fish is thus examined. There is limited information on the use of orange peel and lemongrass powder as natural preservative for smoked fish and this study aims to assess the effect of powdered lemongrass and orange peels on insect infestation of smoked *Clarias gariepinus* and *Mormyrus rume* to fill the information gap.

Materials and Method

Study Area and Experimental Design

The study was conducted at the Department of Fisheries, Modibbo Adama University of Technology (MAUTECH) Yola Adamawa State.

Procurement and preparation of Samples

Fresh fish samples (*Clarias gariepinus* and *Mormyrus rume*) were purchased from fish market in Jimeta Adamawa state. The fish were transported in an insulated container to the Department of Fisheries, MAUTECH. Sweet orange peel (*Citrus sinensis*) was obtained from orange sellers at Jagajaga market near the university school gate, the lemongrass was collected from the departmental fish farm. The orange peels and lemon grass was cut into smaller pieces and air dried at room temperature for 5 days; dried samples were ground into fine powder, left to cool down and stored in air tight containers. The fish was descaled, degutted and washed before allowing to drain for 40 minutes. Drained fish (1Kg) was folded in the traditional way for smoking. The charcoal drum smoking kiln was used to smoke-dry.

Experimental Design

Fish samples were allocated into four treatments with three replicate completely randomized design following Sogbesan and Ibrahim, (2017) methods. The smoke fish were preserved with (10g) different concentration of lemongrass and orange peel powder (Table 1).

Table1: Experimental treatment combination (Sogbesan and Ibrahim, 2017)

SN	DESCRIPTION	TREATMENT
1	0% preservative	TRT1
2	100% orange peel powdered	TRT2
3	100% lemongrass peel powdered	TRT3
4	50+50 orange peel and lemongrass powdered	TRT4

Proximate Analysis of Smoked Fish

The proximate analyses of fish were carried out according to AOAC (2006). Crude protein content of the various samples was determined by the Kjeldahl procedure; crude fibre was the trichloroacetic acid method; crude fat was by the soxhlet extraction procedure; ash (A) was carried out by incineration while, dry matter (DM) and nitrogen free extracts (NFE) were calculated.

Determination of Peroxide Value

Peroxide value (PV) measures the degree of lipid oxidation in fats and oils but not their stability. This was calculated using the formula:

$$PV = \frac{S - BXNX 10}{Samplew(y)}$$

Where S = Sample titration, B = Blank titration, N = Normality of Na₂S₂O₃ solution.

Sensory Evaluation of Smoke Fish Products

The determination of taste, flavour, mouth feel (texture), physical appearance (colour) and general acceptability of the smoked fish products was evaluated using a 7 point hedonic scale (7- Excellent; 6- Extremely good; 5- Very good; 4- Good; 3- Poor; 2- Very poor; 1-Extremely poor) according to Sogbesan and Ibrahim (2017).

Data Analysis

The data obtained was subjected to simple percentages, descriptive statistics and analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 16.1.

Results

Table 2 also shows that there was reduction in the weights in both fish samples and Trt3 for *C. gariepinus* (5.02%) having the lowest weight loss while Trt 1 for *M. rume* (34.4%) having the highest loss.

Table2: Percentage weight of *Clarias gariepinus* and *Mormyrus rume* before and after preservation

Fish species	Treatment	Initial weight (g)	Final weight (g)	% Weight loss
<i>Clarias gariepinus</i>	Trt1	242.5	203.4	16.12 ^a
	Trt2	273.7	222.4	18.74 ^a
	Trt3	248.9	236.4	5.02 ^b
	Trt4	252.7	230.1	8.94 ^b
<i>Mormyrus rume</i>	Trt1	153.3	100.6	34.4 ^a
	Trt2	202.6	163.3	19.4 ^c
	Trt3	215	160.6	25.30 ^b
	Trt4	194.9	155.5	20.22 ^{bc}

Mean on the same column with different superscripts are significantly different p<0.05)

(Trt1 =Control no preservative 0%; Trt2 = fish preserved with 100% orange peel powdered; Trt3=fish preserved with 100% lemongrass powdered; Trt4 = combination of 50+50 orange peel and lemongrass powdered)

The results after 8 weeks of storage (Table 3) show a reduction across treatments in moisture, ash and crude lipid content while, protein and fibre content increased with Trt 4 having the highest increase in crude protein and lower crude fibre. There was decrease in protein content recorded for the control. All the samples had a reduction in moisture content fibre, NFE, and lipid, which could be attributed to weight loss to air.

Figure 1 shows the level of insect infestation and Trt 4 for *Mormyrus* had no insect infestation while *Clarias* across the group was infested at various degree. The peroxide values (Figure 2) show that *Mormyrus rume* had a lower value than *Clarias* across the treatments. The organoleptic test (Figure 3) before and after preservation reveals the control in both fish species having a good acceptance generally. *Clarias* Trt 2 was better in terms of aroma while Trt4 in appearance. *Mormyrus*, Trt 4 high for aroma and Trt 2 was lowest for colour.

Table 3: Proximate Composition of *Clarias gariepinus* and *Mormyrus rume* Pre- and Post-preservation

Fish species	Pre-preservation	Post-preservation			
	Control	Trt1	Trt2	Trt3	Trt4
<i>Clarias gariepinus</i>					
Moisture	14.5 ^a	12.0 ^a	10.5 ^a	11.0 ^{ab}	9.0 ^b
Crude Protein	66.88 ^a	68.12 ^a	67.5 ^a	66.25 ^a	69.38 ^a
Crude Lipid	12.0	11.5	7.0	6.0	5.0
Crude-Fiber	1.06	1.58	3.11	3.03	2.68
Ash	5.0	5.0	6.0	2.0	3.0
Nitrogen free Extract	0.56	1.80	5.89	11.72	10.94
<i>Mormyrus rume</i>					
Moisture	15.0	13.5	11.0	12.0	10.0
Crude Protein	51.88 ^a	54.13 ^a	53.13 ^a	55.0 ^a	55.0 ^a
Crude Lipid	10.50 ^a	10.0 ^a	8.0 ^{ab}	6.5 ^b	7.0 ^b
Crude-Fiber	0.2	0.32	2.39	2.6	1.73
Ash	5.0	1.0	6.5	3.0	4.0
Nitrogen free Extract	17.42	21.8	18.98	21.34	22.27

Data with Different Superscript on the same column are significantly different at $p < 0.05$

(Trt1 = Control no preservative 0%; Trt2 = fish preserved with 100% orange peel powdered; Trt3 = fish preserved with 100% lemongrass powdered; Trt4 = combination of 50+50 orange peel and lemongrass powdered)

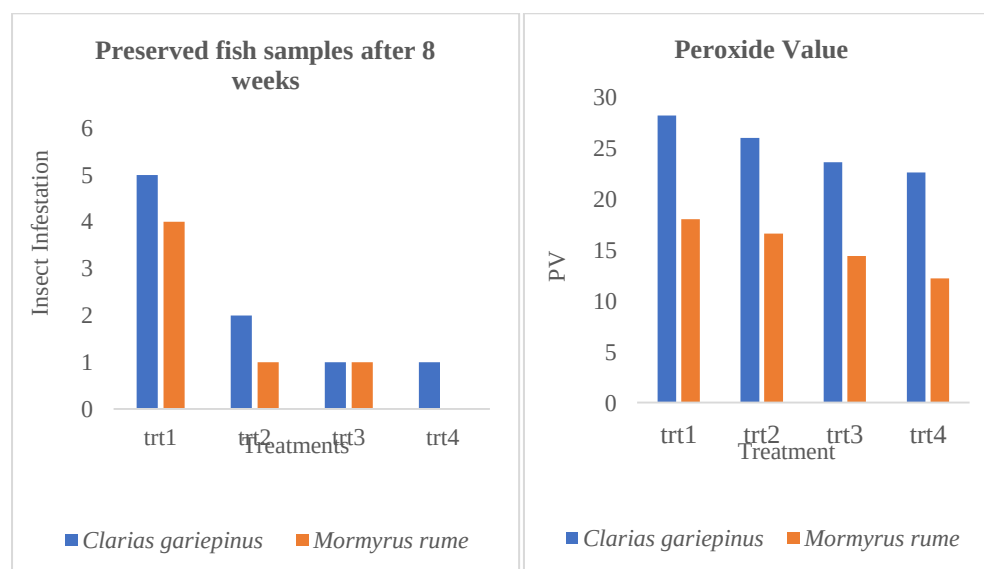


Fig 1: Preserved fish samples after 8 weeks

Fig 2: Peroxide Value

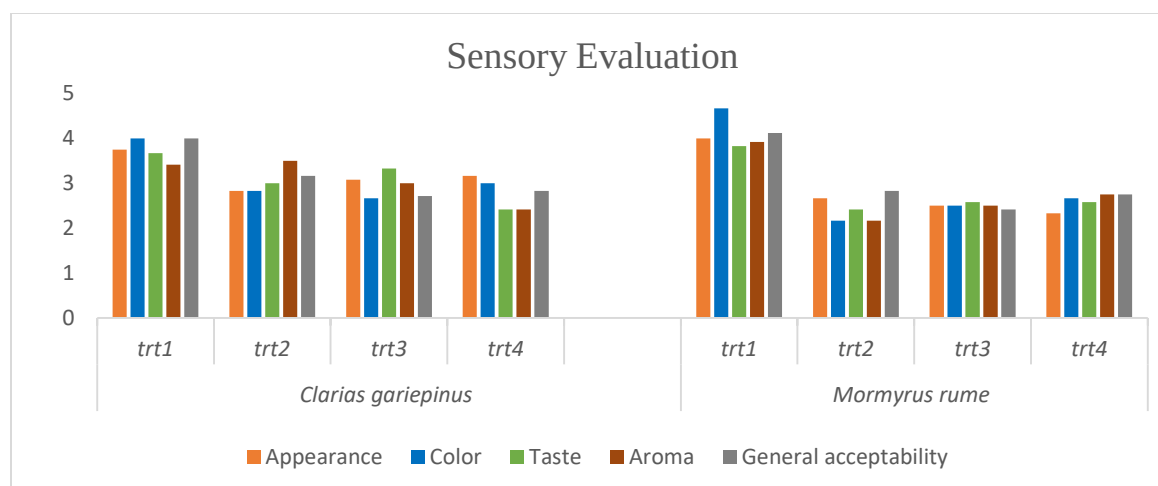


Fig 3: Sensory Evaluation of preserved fish samples after 8 weeks

(Trt1 =Control no preservative 0%; Trt2 = fish preserved with 100% orange peel powdered; Trt3=fish preserved with 100% lemongrass powdered; Trt4 = combination of 50+50 orange peel and lemongrass powdered)

Discussion

The weight loss (Table2) from pre and post preservation of fish sample is an indication that removal of the gut reduces total weight and spoilage due to bacterial action. *Clarias gariepinus* in Trt3 and Trt4 exhibited the lower moisture loss (5.02 and 8.94%) as compared to *Mormyrus rume* to the control without any preservative which agrees with Sigurgisladottiret *et al.* (2000) that final product is dependent on the quality of raw material and time of smoking. Davies and Davies (2009) made a similar observation that the weight loss of the smoked fish was as a result of the drying process. Proximate composition (Table3) shows a significant variation ($p < 0.05$) in almost all the treatment; pre-preservation in both fish species had a higher moisture content while there was reduction in all the post-preservation treatments; crude protein increased gradually while crude lipid decreased; this agrees with Doe *et al.* (1998) that fish processing often results in higher concentration of nutrients like crude protein and fat and that the quality of fish products is influenced by fish species, different processing (including smoking) and storage practices. Abolude and Abdullahi (2005) reported a higher protein concentrated in the flesh of *Bargus filamentous* and *Hydrocynus brevis*. Agbabiaka *et al.* (2012) are of the opinion that pre-treatment increase nutrient as additional nutrients are inherited.

Dermestes spp was identified on the cured fish and this infestation was more on the untreated fish for both species while Trt4 (*M. rume*) was devoid of infestation (Figure 1). Larvae and adults cause qualitative and quantitative losses on the dried product and Agbon *et al.* (2002) also reported loss due to contamination by insect bodies. The sensory evaluation Figure 3 shows that for the two species without preservation *Mormyrus rume* had a higher acceptability (4.12) than *C. gariepinus* generally while for the treated fish, in terms of appearance, aroma, colour, and taste there was a markedly decline in its evaluation though fish treated with 100% orange peel was accepted more. The peroxide value (Figure 2) of catfish shows that Trt4 with a lower value for both species are less prone to rancidity followed by Trt3 as compared to the control. The present result is similar to those obtained by Ligia (2002) for blue striped catfish. In this study, *Clarias gariepinus* exhibited a higher pre -preservation crude lipid and may have contributed to its rancidity as observed in the present study.

Conclusion

Lemongrass and orange peel powder use in fish preservation have exhibited a lower peroxide values and have shown a high tendency in the reduction of insect infestation.

References

- Abdullahi, S. A., and Abolude, D. S. (2005). Seasonal levels of some nutrients in the three Bagrids from two localities in Northern Nigeria. *Nigerian Journal of Scientific Research*, 5(2):43-47.
- Ada, F. B. (2018). Some Metal Elements Concentrations in Snout Fish (*Mormyrus rume*: Valenciennes 1847) from Obubra Region of Cross River, Cross River State, Nigeria. *Insights Aquac Cult Biotechnol* Vol.2 No.1:4

- Adewolu, M. A., Adeniji, C. A., and Adejobi, A. B. (2008). Feed utilization, growth and survival of *Clarias gariepinus* (Burchell 1822) fingerlings cultured under different photoperiods. *Aquaculture*, 283(1-4), 64-67.
- Agbabiaka, L. A., Amadi, A. S., Madubuko, C. U., Nwankwo, F. C. and Ojukannaiye, A. S. (2012). Assessment of nutrients and sensory qualities of brine pre-treated catfish, smoked with two different woods smoke. *African Journal of Food Science*, 6(9), 245-248.
- Agbon, A. O., Ezeri, G. N. O., Ikenweiwe, B. N., Alegbeleye, W. O., Oke, O. and Akomolede, D. T. (2002). A comparative study of different storage methods on the shelf-life of smoke-cured fish. *Journal of Aquatic Sciences*, 17(2), 134-136.
- AOAC (2006). International official methods of analysis of the AOAC (W. Horwitz Edition, 18 the dn. Washington D. C., U. S. A: AOAC International.
- Davies R. M. and Davies O. A. (2009). Traditional and Improved Fish Processing Technologies in Bayelsa State, Nigeria. *European Journal of Scientific Research*, 26(4): pp 539 – 548.
- Doe, P., Sikorski, Z., Haard, N.F., Olley, J. and Pan, B.S. (1998). Basic principles, in Fish drying and smoking: Production and quality (ed. P. Doe), Technomic Publishing Company Inc., Lancaster, Pennsylvania, USA, pp. 13–45.
- Dubey D., Balamurugan K. Agrawal R. C, Vema R. and Jain R. (2011). Evalution of antibacterial and antioxidant activity of methanolic and hydromethanolic of sweet orange peel. *Rec Res Science Technology*.3 (11) 22-5
- Edogbanya, P., Suleiman, M. O. and Olorunmola, J. B. (2019). Comparative study on the antimicrobial effects of essential oils from peels of three citrus fruits. *MOJ Biol Med*. 4(2):49–54. DOI: 10.15406/mojbm.2019.04.00113
- Fawole, O. O. (2002). Morphometry and diet of *Mormyrus rume* in the Lekki lagoon, Nigeria. *Rev. Boil. Trop.*, 50 (2)
- Hussein, N. M., Hussein, M. I., Gadel Hak, S.H., Shaalan, H. S. and hammad, M. A. (2015). Effect of two plant extracts and four aromatic oils on *Tuta absoluta* population and productivity of tomato cultivar gold stone. *Journal of Plant Protection and Pathology*, 6(6), 969-985.
- Idris, G., Omojowo, F, Omojasola, P., Adetunji, C. and Ngwu, E. (2010). The effect of different concentrations of lemongrass on the quality of smoked dried (*Citharinus citharus*). *Nature and science*, 8 (4) 59-60.
- Kanaze, F. I., Termentzi, A., Gabrieli, C., Niopas, I., Georgarakis, M., & Kokkalou, E. (2009). The phytochemical analysis and antioxidant activity assessment of orange peel (*Citrus sinensis*) cultivated in Greece–Crete indicates a new commercial source of hesperidin. *Biomedical Chromatography*, 23(3), 239-249.
- Ligia, V. A. (2002). Hazard analysis critical control point (HACCP), microbial safety, and shelf life of smoked blue catfish (*Ictalurus furcatus*).
- Oikeh, E. I., Oriakhi, K., and Omoregie, E. S. (2013). Proximate analysis and phytochemical screening of *Citrus sinensis* fruit wastes. *The Bioscientist Journal*, 1(2), 164-170.
- Olasebikan, B. D. and Raji, A. (2013). Field Guide to Nigerian Freshwater Fishes: Revised Edition. Published by B.D. OLAOSEBIKAN AND AMINU RAJI. ISBN 978-34760-0- 9. Pp 32,60,65 and 108.
- Reeds, W. J., Burchard, A., Hopson, A. J., Jennas, J. and Yaro, I. (1967) Fish and Fisheries of Northern Nigeria. Ministry of Agriculture, Northern Nigeria. 97pp.
- Shah, G., Shri, R., Panchal, V., Sharma, N., Singh, B. and Mann, A.S. (2011): Scientific basis for the therapeutic use of *Cymbopogon citratus*, staff (Lemongrass). *Journal of Advanced Pharmaceutical Technology and Research*, 2(1):3-8.
- Sigurgisladottir, S., Sigurdardottir, M. S., Torrisen, O., Vallet, J. L., and Hafsteinsson, H. (2000). Effects of different salting and smoking processes on the microstructure, the texture and yield of Atlantic salmon (*Salmo salar*) fillets. *Food Research International*, 33(10), 847-855.
- Skrede, G., and Wrolsted, R. E. (2002). Flavonoids and other polyphenolics in grapes and other berry fruit. *Functional foods biochemical processing aspects*, 2, 71-130.
- Sogbesan, O.A. and Ibrahim, P. (2017). Assessment of Smoked Fish Quality using two smoking kilns and hybrid solar dryer on some commercial fish species in Yola, Nigeria. *Journal of Animal Research and Nutrition* 2(1):6
- Toungos, M. D. (2019). Lemon grass (*Cymbopogon, L. Spreng*) valuable grass but underutilized in Northern Nigeria. *International Journal of Innovative Food, Nutrition and Sustainable Agriculture*, 7(2), 6-14

Tripoli, E., La Guardia, M., Giammanco, S., Di Majo, D., and Giammanco, M. (2007). Citrus flavonoids: Molecular structure, biological activity and nutritional properties: A review. *Food chemistry*, 104(2), 466-479.

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Fish Handling and Processing Techniques in Asa Dam Area and Ilorin Metropolis, Kwara State

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Abstract

This survey was carried out from August to September, 2021 to find out the handling, processing and preservation techniques practiced by the fisher folks in Asa dam Area and in Ilorin metropolis, Kwara State. A combination of structured questionnaire, personal communication and on-sight assessment were used. Result showed that fish were commonly smoked when not sold, most cafteria in Ilorin metropolis utilize fresh catfish to make fish pepper soup. Also common within ilorin metropolis is fish barbeque in which tilapia and cattfish from Asa dam river and ponds around are used and they are common delicacies in the evenings. The handling and processing techniques are poor, crude and below standard and this will invariably lead to economic loss. The use of modern processing equipment are thereby recommended.

Keywords: Handling, preservation, processing, fisher-folk and fish.

Introduction

Fish is one of the most important animal-sourced protein foods across Nigeria and most part of the Africa (Desiere *et al.*, 2018). It is a highly perishable and need careful handling (Nwaigwe, 2017). The rate of spoilage is influenced to a large extent by the high ambient temperature. Fish accounts for about 40% protein intake with Fish consumption at 13.3kg/per person per year (FAO 2018). The demand for fish in Nigeria is estimated at 3.61 million metric tonnes in 2018. This may be responsible for Nigeria being one of the largest importers of fish in the developing world. Nigeria spends over 288 billion naira on annual fish importation (Central Bank of Nigeria 2017 and FAO 2018). Despite the deficit in fish demand, there still exist some level post-harvest losses because of poor handling, processing and preservation technology. Studies have shown that post-harvest losses in Nigeria are related to poor handling, processing, preservation, hygiene, quality deterioration and microbial spoilage (Omojowo and Ihuahi, 2006; Ihuahi *et al.*, 2010 and Bate and Bendall, 2010).

Fish processing entails series of actions applied by the fisher-folk and fish processors to preserve their fish products from the time fish is caught until it reaches the consumer. However, factors such as the delay in handling the catch, poor control of fish temperature, poor standards of gutting are often deleterious on the quality of fish and results in reduction of shelf life and loss of weight. Poor fish handling refers to inappropriate practices used by the fishermen while handling their fish products after harvest such as fish placed on dirty surface; use of dirty boxes/baskets/bowls; washing of fish in dirty water; fish thrown/displayed on the ground; beating fish with stick after harvest or stepping on fish; delay in gutting the fish after harvest; use of dirty knives or other objects to remove the fish scale. Due to these poor handling techniques, fish gets subjected to physical, chemical and biological hazard leading to increased microbial contaminations which hasten the spoilage rate of fish. Fish preservation is generally carried out to improve the shelf life of fish. There are several fish preservation techniques such as smoke-drying, oven-drying, sun-drying, cooking, barbequing, salting or wet salting employed by fisher folks fish processors to preserve fish products. These techniques, if appropriately done helps prevent fish from spoilage, damage or destruction due to parasite and bacterial action. In artisanal fishery, the commonest preservation technique is smoking using wood in the smoking kilns or oven. This survey was carried out to find out the handling, processes and preservation techniques practiced by the fisher folks/processors of fish in villages around the Asa dam River and in Ilorin metropolis, Kwara state.

Materials and Methods

The survey on the handling processes and fish processing techniques done by fisher folks/fish processors in the Asa Dam area and Ilorin metropolis Kwara State was carried out using combination of structured questionnaire, personal communication and on-sight assessment of the handling and processing methods. This survey was carried out

August to September, 2021. Some of the parameters investigated are major types of fish processed, handling methods, processing and preservation techniques.

Results

Handling and Processing Methods in the Asa Dam Area

Fishing activities is commonly carried out on the Asa Dam, in Ilorin, Kwara State by fisher folks using wooden canoes (Plate 1.) The most commonly caught and processed fishes in this metropolis include the cichlides (*Tilapia zillii*, *Oreochromis niloticus*, *Sarotherodon gallileus*), Clariidae (*Clarias anguillaris*), *Bagrus bayad*, *Brycinus nurse* and *Schilbe*. Fishes obtained from the canoe (Plate 1) are poured onto the rock (Plate 2) for sorting, de-scaling and degutting (Plate 3). The fish are then rinsed with the dirty water from the Asa river and conveyed in bowls (Plate 4) to their homes in nearby villages to be smoke dried. The major preservation technique practiced among the fish processors around the Asa dam river is the smoke-drying method. The fish are smoke dried using drums as shown in Plate 5. The smoking klin are top loaded and plenty firewood are placed in the combustion chambers (Plate 5b) there by resulting in excessive fire and smoke which could result in charring of some of the fish if not closely monitored. The direct exposure of the fish to smoke will cause build up of smoke on the fish and may result in high content of polyaromatic hydrocarbon (PAH) which could be detrimental to health when consumed. This also result in the poor appearance of the fish after processing. The dried fishes are usually marketed within their neighbourhood.

Processing Methods in Ilorin Metropolis

In Ilorin metropolis, fish are oven-dried, cooked for pepper soup or barbequed. Fish processed are majorly obtained from pond culture and also the Asa Dam River. The fish obtained from pond culture consist mainly of clarias specie and hybrids while big Tilapias specie are obtained from the Asa Dam River.

The fish are usually, poured into a big bowl and salted, They are degutted but the gills are not removed, washed and arranged on a rack to strain. Salt is sprinkled on the fish and the racks are arranged in the oven and left to dry . After drying they are removed and arranged on the wooden rack to cool.

Oven Dried Fish With Charcoal

Drying of catfish in locally fabricated ovens (Figure 7a) that use charcoal as its heat source are majorly the preservation techniques practiced by fish processors. They obtain the catfish from pond culture.

Fish Barbecue

Fish barbecue is one of the major processing/preservation techniques practiced by fish processors at Ilorin metropolis. The major fish used in making barbecue fish are tilapia and catfish which are obtained from the Asa Dam River and from pond culture respectively. They majorly process the fish in the evening around 5pm and await their customer. The sales of fish barbecue is mostly in the evenings. The processing involved cleaning the fish, degutting and washing. The washed are some placed over dry heat for scalding (Plate 8b). The fish is then placed in foil paper and garnished with already prepared sauce (pepper, tomatoes, maggi, ginger, garlic, onion blends). Some add unripe plantain inside to garnish it and the foil is wrapped and placed over charcoal heat to cook. When ready the fish are then displayed for customers to buy (Plate 8a to 8c).

Fish Pepper Soup

Most cafteria in Ilorin metropolis use fresh catfish to make catfish pepper soup. The fishes are cut into chunks, degutted and washed. The cut pieces are put in a pot containing peppersoup spices (ginger, garlic, pepper, uziza, scent leaf, maggi and salt). The fish is boiled in the spiced water for some minutes. They are served in bowls to customers on demand.



Plate 1: Fisher folk landing from his catch from the Asa Dam River



Plate 2: Fishes are poured on the rock after catch



Plate 3a and b: Fisher folk de-scaling and de-gutting fish caught from the Asa dam River, Iloirn



Plate 4: Fish un-deguttred before smoking. Plate 5: Containers used by fish mongers to carry fish.



Plate 6a and b: Smokeoke drying process in the villages near Asa dam River



Plate 7A: Locally Fabricated charcoal Oven



Plate 7b: Catfish drying in the charcoal oven



Plate 7c: Dried catfish arranged on wooden rack



Plate 8a and 8b Tilapia and Catfish barbeque displayed for customers



Plate 8c: Barbeque fish wrapped with foil on display

Discussion

The fish species found in Asa Dam area are Cichlides (*Tilapia zillii*, *Oreochromis niloticus*, *Sarotherodon gallileus*), Clariidae (*Clarias anguillaris*), *Bagrus bayad*, *Brycinus nurse* and *Schilbe*. These results are similar to the one reported by Araoye, (2009) where he reported 11 families namely, Osteoglossidae, Anabantidae, Characidae, Schilbedae, Cyprinidae, as occurring seasonally while Mormyridae, Cichlidae, Mochokidae, Characidae, Bagridae and Clariidae as more common. The various processing methods reported in this survey agreed with earlier studies of poor handling, crude processing and preservation methods in most fishing villages in Nigeria (Eyo, 2001, Davies (2005) and Ihuahi *et al.*, 2010).

Conclusion

Poor fish handling and processing techniques are practiced by fisherfolks/ fish processors in villages around the Asa dam River. Processing is generally carried out when fisher folks could not sell their fish fresh. Their preservation techniques are crude and below standard resulting in economic loss. Other processing and preservation techniques like fish frying, fish roasting (Barbeque), fish pepper-soup were the efforts and business initiatives of men and women that refused to be lazy but resolved to make ends meet. Hence the introduction of modern processing techniques and equipment to the fish processors is paramount, as this will add value to the processed fish, the processors will then earn more income to improve their livelihood.

References

- Araoye, P. A. (2009). Physical Factor and their Influence on Fish Species Composition in Asa Lake, Ilorin, Nigeria. In: Rev. Biol. Trop. 57 (1-2): 167-175.
- Bate, E.C and Bendall, J.R. (2010). Changes in fish muscle after death. In: *British Medical Bulletin*, (12): Pp2305.
- Davies, R. M. (2005). Development of Appropriate Technology of fish processing in Nigeria. A paper presented at a one-day workshop on intensive fish farming on Thursday, 24th February 2005.
- Desiere, S., Hung Y., Verbeke, W. and D'haese, M. (2018). Assessing Current and future meat and fish consumption in Sub-Saharan Africa. Learnings from FAO Food Balance Sheets and LSMS household survey data'. *Global Food Security*. (16), 16-126.
- Eyo A.A. (2001). *Fish Processing Technology in the Tropics*. University of Ilorin Press, Ilorin. Pp.402.
- FAO 2018 –The State of world Fisheries and Aquaculture 2018- Meeting the Sustainable Development Goals. (Rome: Food and Agricultural Organisation of the United Nations, 2018).
- Ihuahi J.A, Egila J. and Omojowo F.S (2010). Storage Life of Tilapia (*Oreochromis niloticus*) in Ice and Ambient Storage. In: *Researcher*, (5):39-44.
- Omojowo F.S and Ihuahi J.A (2006). Microbiological Quality and Safety of smoked fish from Kainji Lake area. In *African Scientist*, (7) 1- 4..
- Nwaigwe, U. (2017). Fish preservation and processing. *CyTA - Journal of Food*. 1.
- Central Bank of Nigeria. (2017). Annual Report.

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Growth Performance, Proximate Composition and Economic Analysis of *Clarias gariepinus* (Burchell, 1822) Fed Graded Levels of Groundnut Cake in Plant Protein Based Diet

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Abstract

This study assessed the effect of defatted groundnut cake in plant protein-based diet on the Growth Performance, proximate composition and economic analysis of *Clarias gariepinus* Juveniles fed varied inclusion of defatted groundnut cake (DGNC). Fingerlings fish (n=360), weighing 6.88±0.20g were randomly allocated to six diets containing varied inclusion of defatted groundnut cake in the formulated basal plant protein-based diet with 0% (Control), 20% (T₁), 40% (T₂), 60% (T₃), 80% (T₄) and 100% (T₅) inclusion defatted groundnut cake. The fish were fed to satiation with the diets for 8 weeks. Each treatment was in triplicate. Fish fed with 20% (T₁) inclusion of DGNC had a significantly (p>0.05) higher value of 16.48±6.56 and least value of 8.60±1.90 in 100% (T₅). Feed conversion ratio increases as the inclusion levels increases with the least values in T₁ and the higher value in fish fed diet T₅. Proximate composition of fish fed graded inclusion of DGNC varied significantly. However, varied inclusion of DGNC in plant protein-based diet had no significant (p<0.05) influence on Profit index, Net production value and Gross profit. The result from this present study revealed that an increase in the inclusion level of DGNC beyond 20% resulted in a decline in growth rate of *Clarias gariepinus* juveniles but does not have influence on the economic analysis.

Keywords: Growth Performance, Proximate Composition, Economic Analysis, Defatted Groundnut Cake

Introduction

Partial replacement of fishmeal in the diet of different cultured fish species with plant-based protein ingredient sources has been achieved (Robaina *et al.*, 1995). However, research priority in aquaculture nutrition has been geared towards mitigation and possibly eliminate fish meal by replacement with plant or grain by-products in developing low-cost fish feeds (Al-Kenawy *et al.*, 2008; Ajani *et al.*, 2016; Cai *et al.*, 2017). Although, Complete replacement of fishmeal by plant protein sources has been achieved most especially with soyabean based diet (Oyedokun *et al.*, 2019). However, the inclusion ratio of plant protein ingredients such as groundnut cake has not been determined due to the infancy stage of researches in plant protein-based diets. There is therefore need to determine inclusion levels of groundnut cake in plant protein-based diets due to its high protein content, palatability with better binding properties (Fapohunda, 2008).

Groundnut cake is an oilseed by-product obtained after oil extraction from groundnuts either by mechanical or solvent means (Agbo *et al.*, 2011). Its protein content is high of (40-45% crude protein) but, like other plant products, it has sub-optimal levels of certain amino acids such as cystine, methionine, and lysine, and is deficient in calcium and vitamin B12 (Jauncey 1998). It is abundant, cheap and the most easily available dietary plant protein source for domestic animals. Although, GNC is lacking in some essential amino acids but combining it with fishmeal, which is rich in methionine and lysine, will go a long way to produce a high nutritive feed and better growth in fish.

Several studies have reported that partial replacement of groundnut cake in with fish meal is relatively such as Ovie and Ovie, 2007 (10% inclusion levels); Agbo *et al.*, 2011 (20% inclusion levels). Agbo *et al.*, 2011, further reported that the inclusion rates of groundnut meal/cake in experimental and practical diets for aquatic animals are reported to be in the range of 5% to 61%. However, research on the inclusion rate of groundnut cake is yet to be establish in *Clarias gariepinus* when fed plant protein-based diet. Therefore, the study will assess the effect of varied inclusion of DGNC as the plant protein-based diet on growth performance, flesh quality and economic analysis of *C. gariepinus*.

Materials and Methods

The feeding trial was conducted at the Fisheries and Aquaculture Laboratory, located at the Central Laboratory of Adekunle Ajasin University, Akungba-Akoko, Ondo State. *Clarias gariepinus* juveniles (n=360) aged eight weeks weighing 6.88 ± 0.30 g were purchase from a reputable fish farm in Ikare Akoko. Iso- nitrogenous basal diet in each plant protein diet supplemented with varied inclusion levels of DGNC was used to formulate six (6) dietary treatment. The diets were formulated to 40% crude protein (Fatunroti *et al.*, 1989). Gross composition of experimental diets is shown in Table 1. The ingredients used to formulate feeds were thoroughly mixed together and each diet mixture was pelleted using 2mm pellet die to form noodle-like strands, which were manually crumbled into a suitable size for the *Clarias gariepinus* juveniles. The pellets were sundried, packed into transparent, air-tight plastic container and stored in a cool dry place to prevent fungal growth. The six dietary treatments of varied inclusion of defatted groundnut cake (DGNC) (g/100g) in plant protein based diet were formulated as follows: T₀ (control) = 0% inclusion of DGNC, T₁ = 20% (DGNC), T₂ = 40% (DGNC), T₃ = 60% (DGNC), T₄ = 80% (DGNC), T₅ = 100% (DGNC).

Fish feeding trial

The experiment was conducted at the Fisheries and Aquaculture Laboratory with 18 plastic tanks of 25L capacity for 8 weeks. Every three days, each tank was supplied with well water up to 80% capacity. The water was replaced to prevent fouling from feed residues and maintain relatively uniform physico-chemical parameters. The dietary treatments were six and each were on triplicates with 20 fish each. The fish were weighed and randomly allocated to experimental tanks. They were thereafter acclimatized for 14 days with 2mm skretting diet. Water temperature was kept at optimum range of 27.41^oC to 29.62^oC. The fish were left for 2 days unfed before the experiment. The fish were fed to satiation twice daily (08:00 and 17:00 hours). The weight of the fish was monitored weekly. Water quality was monitored weekly. The experiment lasted for 56days.

Table 1: Gross composition (g/100g DM) of experimental diets at 40% crude protein level.

INGREDIENTS (g/100g)	T ₀	T ₁	T ₂	T ₃	T ₄	T ₅
Soyabean	85.8	68	51	34	17	-
Groundnut Cake	-	17.8	34.8	51.8	68.8	85.8
Methionine	0.4	0.4	0.4	0.4	0.4	0.4
Lysine	0.6	0.6	0.6	0.6	0.6	0.6
Maize	10.00	10.00	10.00	10.00	10.00	10.00
Fish oil	1.00	1.00	1.00	1.00	1.00	1.00
Salt	0.1	0.1	0.1	0.1	0.1	0.1
Vitamin C	0.2	0.2	0.2	0.2	0.2	0.2
Calcium carbonate (CaCO₃)	1.4	1.4	1.4	1.4	1.4	1.4
Vitamin premix	0.5	0.5	0.5	0.5	0.5	0.5
TOTAL	100	100	100	100	100	100

T₀ (0% Inclusion of groundnut cake), T₁ (20% inclusion of groundnut cake), T₂ (40% inclusion of groundnut cake), T₃ (60% inclusion of groundnut cake), T₄ (80% inclusion of groundnut cake), T₅ (100% of groundnut cake). *Vitamin A 4,000,000IU, Vitamin D3 800,000IU, Vitamin K3 1,600mg, Vitamin B1 4,000mg, Vitamin B2 3,000mg, Vitamin B6 3,800mg, Vitamin B12 3mcg, Nicotonic Acid 18,000mg, Pantothenic Acid 8,000mg, Folic Acid 800mg, Biotin 100mcg, Choline Chloride 120,000mg, Iron 8,000mg, Copper 800mg, Manganese 6,000mg, Zinc 8,000mg, Iodine 400mg, Selenium 400mcg, Vitamin C (Coated) 60,000mg, Inositol 10,000mg, Cobalt 150mg, Lysine 10,000mg, Methionine 10,000mg and Antioxidant

Table 2: Proximate Composition Of Varied Inclusion Level Of Defatted Groundnut Cake Feed

Samples (0%)	T0 (control)	T1	T2	T3	T4	T5
Crude Protein	28.84±0.27 ^f	35.95±0.15 ^c	36.47±0.05 ^b	39.03±0.24 ^a	34.63±0.04 ^d	34.33±0.03 ^e
Ether Extract	6.65±0.15 ^b	7.00±0.10 ^a	7.15±0.05 ^a	6.70±0.10 ^b	6.60±0.10 ^b	6.35±0.05 ^c
Ash Content	7.50±0.10 ^a	6.80±0.10 ^c	7.35±0.15 ^{ab}	6.45±0.15 ^d	6.65±0.05 ^{cd}	7.27±0.14 ^b
Crude Fibre	3.87±0.04 ^a	3.63±0.03 ^b	3.53±0.03 ^b	3.30±0.10 ^c	3.50±0.10 ^b	3.60±0.10 ^b
Dry Matter	90.96±0.06 ^d	91.34±0.02 ^b	91.29±0.01 ^b	91.91±0.05 ^a	90.68±0.02 ^e	91.19±0.04 ^c

a,b,c,d, e, f =indicate that means on the same row but with different superscripts are statistically significant (P<0.05)

Growth studies

Calculations on growth performance and feed utilization were according to Fasakin *et al.* (2000). Data on Weight Gain (WG), Feed Conversion Ratio (FCR), Protein Intake (PI), Feed Intake (FI), Protein Efficiency Ratio (PER), Specific Growth Rate (SGR), Gross Protein Retention (GPR), and Survival Rate (SR) were taken bi-weekly throughout the duration of the study.

Flesh sampling and analysis

Flesh was randomly sampled from the experimental tanks for proximate analysis. The flesh samples were packed and put in a cooler containing ice block so as to maintain their body temperature. The flesh samples were analysed for chemical analysis.

Chemical composition

Feed ingredients, diets and the whole body of fish were analysed chemically (AOAC, 2005). All the determinations were in triplicates.

Economy of feed production and rearing of fish

The cost was based on current prices of feed ingredients in the experimental locality (Nigeria) at the time of the experiment. The economic evaluations of the diets were calculated from the following methods (Aderolu and Oyedokun, 2008).

Profit Index (PI) = NPV

Cost of feeding (₦)

Investment Cost Analysis = Cost of feeding (₦) + Cost of Juveniles stocked (₦)

Gross Profit (GP) = NPV (₦) – ICA (₦)

Net Production Value (NPV) = Mean Weight gain of fish (g) × Total survival (n) × Cost per kg

Benefit cost ratio (BCR) = $\frac{\text{NPV (₦)}}{\text{ICA}}$

Incidence of cost = $\frac{\text{Cost of feeding}}{\text{Weight of fish produced}}$

Statistical Analysis

The results were subjected to a one-way ANOVA and data were analyzed using statistical SPSSv20 (SPSS Inc., Chicago, IL, USA). Differences between mean were compared using Duncan's Multiple Test Range of differences (p<0.05) among dietary treatments.

Results

Growth performance and feed utilization of *C. gariepinus* fed varied inclusion of defatted groundnut cake as shown in Table 3. *C. gariepinus* fed diet T₁ had a significantly higher weight gain value of 16.48±6.56 than other treatments and least in T₅ (8.60±1.90). However, the least value of FCR was observed in fish on T₁ (1.74±0.85) and the values increased as the inclusion level increased. Feed intake and protein intake of fish on T₅ (5.17±0.37; 2.07±0.15) was similar (p>0.05) to those on control diet but were superior to those on other diets. Higher (p>0.05) feed efficiency ratio was observed in fish on T₁ than other diets. Varied inclusion of defatted groundnut cake in plant protein diet had no significant influence on gross efficiency feed conversion, protein efficiency ratio, specific growth rate and survival rate.

Proximate composition of *C. gariepinus* fed varied inclusion level of defatted groundnut cake varied significantly among the treatment as shown in table 4. Dry matter of the experimental fish varied significantly among diets with the higher value in fish on control diet (75.90±0.20) and least in T₁ (73.42±0.1). Fish on diet T₅ (71.45±0.43) had higher (p>0.05) value for crude protein and least in control diet. Control diet had the higher ether extract value of 8.60±0.10, however, the values reduce as inclusion levels increases. Significantly higher value of Ash content was observed in fish on T₁ and the least in T₅ (3.20±0.10). The moisture content was significantly higher in fish on diet T₁ (26.28±0.13) and least values in diet T₂ and control diets.

Table 3: Growth Performance and Feed Utilization of *C. gariepinus* Fed Varied Inclusion of Defatted Groundnut Cake

PARAMETERS	T0	T1	T2	T3	T4	T5
Initial Mean Weight	6.91±0.00 ^a	6.88±0.06 ^a	6.85±0.04 ^a	6.89±0.03 ^a	6.91±0.04 ^a	6.91±0.02 ^a
Weight Gain	12.18±0.29 ^{ab}	16.48±6.56 ^a	14.90±1.92 ^{ab}	12.48±1.30 ^{ab}	13.09±2.19 ^{ab}	8.60±1.90 ^b
FCR	1.96±0.24 ^{ab}	1.74±0.85 ^b	1.78±0.30 ^{ab}	2.07±0.50 ^{ab}	2.72±0.95 ^{ab}	2.93±0.33 ^a
GEFC	52.45±9.01 ^a	68.65±35.44 ^a	57.30±9.14 ^a	49.99±10.94 ^a	40.45±16.25 ^a	32.59±7.88 ^a
Feed Intake	4.78±0.28 ^a	3.40±0.29 ^b	3.65±0.17 ^b	3.66±0.45 ^b	3.69±0.13 ^b	5.17±0.37 ^a
Protein Intake	1.91±0.11 ^a	1.36±0.12 ^b	1.46±0.07 ^b	1.46±0.18 ^b	1.48±0.05 ^b	2.07±0.15 ^a
FER	0.52±0.07 ^{ab}	0.68±0.35 ^a	0.57±0.09 ^{ab}	0.50±0.11 ^{ab}	0.41±0.16 ^{ab}	0.34±0.35 ^b
PER	2.48±0.05 ^a	3.48±1.87 ^a	3.11±0.27 ^a	2.58±0.46 ^a	2.21±0.83 ^a	1.96±0.64 ^a
SGR	9.28±0.05 ^a	9.80±1.07 ^a	9.75±0.18 ^a	9.34±0.39 ^a	8.93±0.77 ^a	8.55±0.76 ^a
Survival Rate	97.50±3.54 ^a	86.67±10.41 ^a	88.33±7.64 ^a	96.67±2.89 ^a	86.67±2.89 ^a	95.00±0.00 ^a

a,b = indicate that means on the same row but with different superscripts are statistically significant (P<0.05). SGR = Specific growth rate, FCR = Feed conversion ratio, PER = Protein efficiency ratio, FER = Feed efficiency ratio, GEFC = Gross efficiency feed conversion.

Table 4: Proximate Composition of *Clarias Gariepinus* Fed Varied Inclusion Level Of Defatted Groundnut Cake

Parameter %	Control T ₀	T ₁	T ₂	T ₃	T ₄	T ₅
Dry Matter	75.90±0.20 ^a	73.42±0.1 ^c	74.95±0.15 ^b	74.64±0.02 ^c	74.97±0.05 ^b	74.24±0.12 ^d
Crude Protein	57.90±0.20 ^f	61.04±0.21 ^d	59.58±0.53 ^e	63.90±0.15 ^c	69.98±0.38 ^b	71.45±0.43 ^a
Ether Extract	8.60±0.10 ^a	8.05±0.15 ^{bc}	8.20±0.10 ^b	7.95±0.15 ^c	7.50±0.10 ^d	7.25±0.15 ^e
Ash Content	3.95±0.15 ^b	4.60±0.10 ^a	4.20±0.10 ^b	4.05±0.15 ^b	3.40±0.20 ^c	3.20±0.10 ^c
Moisture Content	24.50±0.20 ^d	26.28±0.13 ^a	24.48±0.42 ^d	25.23±0.11 ^c	25.00±0.02 ^c	25.61±0.02 ^b

a,b,c,d,e,f = indicate that means on the same row but with different superscripts are statistically significant (P<0.05). Economic analysis of fish fed varied inclusion of defatted groundnut cake is shown in Table 4. Varied inclusion of defatted groundnut cake in plant protein-based diet had no significant effect on profit index, net production value, gross profit and benefit cost. Fish fed control diet had a significantly higher value for Investment cost analysis and least in T₄. However, higher incidence cost ratio value of 9.29±4.49 was observed in fish on T₅.

Table 5: Economic Analysis of *Clarias gariepinus* Fed Varied Inclusion of defatted Groundnut Cake

Parameter	T0	T1	T2	T3	T4	T5
PI	3.82±0.29 ^a	8.53±4.92 ^a	7.37±0.87 ^a	6.28±1.59 ^a	7.00±2.08 ^a	3.57±1.76 ^a
NPV	2986.95±185.19 ^a	4670.80±2690.32 ^a	4205.30±633.98 ^a	3232.10±658.49 ^a	3202.10±1056.69 ^a	2476.65±1068.08 ^a
ICA	1383.40±11.96 ^a	1152.10±47.51 ^b	1169.58±26.53 ^b	1120.42±68.54 ^{bc}	1055.13±15.41 ^c	1307.09±49.36 ^a
GP	1603.55±197.16 ^a	3518.70±2697.86 ^a	3036.05±614.28 ^a	2111.65±660.47 ^a	2146.97±1043.43 ^a	1169.57±1117.45 ^a
ICR	7.56±0.40 ^{ab}	4.05±1.92 ^b	3.97±0.54 ^b	4.91±1.14 ^b	4.25±1.04 ^b	9.29±4.49 ^a
BCR	2.16±0.16 ^a	4.07±2.35 ^a	3.59±0.48 ^a	2.89±0.63 ^a	3.03±0.96 ^a	1.91±0.89 ^a

a,b=indicate that means on the same row but with different superscripts are statistically significant (P<0.05). PI= Profit Index, NPV=Net Production Value, ICA= Investment Cost Analysis, GP= Gross Profit, ICR= Incidence Cost Ratio, BCR= Benefit Cost Ratio

4. Discussion

The result obtained revealed that an increase in the inclusion level of DGNC beyond 20% results in a decline in growth rate of *Clarias gariepinus* juveniles as shown in Table 3. The weight gain of *C. gariepinus* juveniles decreased as the inclusion of DGNC increased in the diets. This observation supports the findings of Dienyeet *al.* (2014) who noted that weight gain of *Clarias gariepinus* decreased as *Moringa oleifera* leaf meal increased in the diets. The decreased observed could be as a result of the presence of anti-nutrients (such as cyanogenic glycosides, phytic acid and tannin) in the groundnut. Furthermore, Richter *et al.* (2003) also observed that, the higher the inclusion level of *Moringa oleifera* leaf meal with fish meal, the lower the growth performance because of the presence of anti-nutrients such as phenol, tannins, phylates and saponins.

There were decreases in the values of specific growth rate (SGR) of the experimental fishes with increasing level of DGNC in the diet. Anti-nutritional factors contained in DGNC based diet were probably responsible for retarded growth response of the fish. The decrease in the value of specific growth rate (SGR) could be due to the difference in the inclusion level of DGNC in the diets. SGR values seen in this study were parallel with those reported by Erfanullah and Jafri (1998), Alegbeleye *al.* (2001) and Ochanget *al.* (2007), who acknowledged that SGR of *Clarias gariepinus* post fingerlings fed control diet, were higher than those fed on diets containing leaf meals. The trend in SGR of the experimental fish in this study might be an indication of their responses to the varied dietary inclusion levels of groundnut cake.

Furthermore, increase inclusion levels of DGNC reduced protein efficiency ratio and feed intake while feed conversion ratio increased. This conforms with Faturoti (1989) that reported that poor palatability of supplementary diets caused reduced feed intake in African mud catfish. The best survival rate (97.50%) was obtained in fish fed with no inclusion level of DGNC. This result was against the findings of Farahiet *al.* (2012) who concluded that survival rate of fish was promoted in diets supplemented with *Mellisa officinalis* and *Aloe vera*. The highest protein intake (2.07) was obtained in fish fed 100% (T5) inclusion of DGNC while the lowest value (1.36) was obtained in fish fed 20% (T2) inclusion of DGNC.

The proximate composition of the flesh of *Clarias gariepinus* in this study showed significant difference ($P < 0.05$) between the control treatment and other treatments, in terms of crude protein, ash, moisture, ether extract and dry matter. Increase in the level of defatted groundnut cake (DGNC) with dietary amino acid supplementation resulted in the increase in the flesh protein and decrease in flesh ether extract. This is consistent with the results of Robinson (1991) who fed channel catfish diets with increasing levels of lysine. This is similar to the research finding of Olasunkanmi (2011) in *C. gariepinus* fed CMM (Cooked Mucuna Meal), Alegbeleye (2005) in *O. niloticus* fed Housefly Maggot Meal (Magmeal) diets and Afeet *al.* (2019) in *O. niloticus* fed autoclaved cottonseed meal. Sotolu (2010) reported higher values of fish carcass protein than control values in fish fed *Leucaena leucocephala* seed meal and attributed his observation to different utilization levels of the diets. This indicates that there was protein synthesis and increased tissue production in the fish.

However, the moisture content of flesh composition of *C. gariepinus* fed all treatments increased with increasing level of DGNC and significantly different from each other. This is contrary to the result observed by Olasunkanmi (2011) and Afeet *al.*, 2019 that observed no differences in the moisture content when *C. gariepinus* fingerlings was fed with *Acacia auriculiformis* leaf. Ether extract also decreases as the inclusion level of DGNC increases and this was in agreement with the observation of Olasunkanmi (2011) when *C. gariepinus* was fed with CMM (Cooked Mucuna Meal) and TMM (Toasted Mucuna Meal) based diet. However, Abeer Aziza *et al.* (2019) reported contrary result with an increase in flesh ether extract after feeding *O. niloticus* with different protein sources. Flesh composition shows significant differences in ash, moisture and protein content between experimental groups. This was contrary to the result of Abeer Aziza *et al.* (2019) when *O. niloticus* was fed different protein sources.

Conclusion

The growth rate parameters and economic analyses of diet fed to *C. gariepinus* using groundnut cake have proven to be nutritive source of protein and a good replacement for soybean meal at 20% inclusion level in formulating aqua feed for *C. gariepinus* juveniles without deleterious effect. The profit index and benefit cost ratio showed that Diet T1 performed best compared to other fish fed with diet having above 20% inclusion level.

References

- Abeer Aziza and AmrAbd El-Wahab, (2019). Impact of partial replacing of dietary fish meal by different sources on the growth performance of Nile Tilapia (*Oreochromis niloticus*) and Flesh Composition. *Journal of Applied Science*, 19: 384-389.
- Aderolu, A. Z. and Sogbesan, O. A. (2010). Evaluation and Potential of Cocoyam as Carbohydrate Source in Catfish, (*Clariasgariepinus*) [Burchell, 1822]. Juvenile Diets. *African Journal of Agriculture Research*, 5 (6): 453 – 457.
- Afe O. E. and Omosowone O. O (2019). Growth and feed utilization in *Clariasgariepinus*fingerlings fed on *Acacia auriculiformis*leaf supplemented diets. *International Journal of Fisheries and Aquaculture*.pg 57-59.
- Agbo N. W., D. Adjei-Boateng and K. Jauncey (2011): The Potential of Groundnut (*Arachis hypogaea* L.) By-Products as Alternative Protein Sources in the Diet of Nile Tilapia (*Oreochromis niloticus*), *Journal of Applied Aquaculture*, 23:4, 367-378. <http://dx.doi.org/10.1080/10454438.2011.627780>

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Growth Response and Proximate Profiles of *Clarias gariepinus* Fed Graded Levels of *Spirulina* Supplemented Diets

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Abstract

This research was conducted to ascertain the growth indices and proximate profiles of *Clarias gariepinus* fed with graded levels of *Spirulina* inclusion diets. Pearson square method was used to formulate four diets with crude protein of 40%. The diets had 0 % (T1), 10% (T2), 20% (T3) and 30% (T4) spirulina inclusion levels respectively. One hundred and eighty fingerlings were randomly distributed into twelve fiber tanks and grouped in threes to form four treatments (T1a-c to T4a-c). Fish in each tank were fed 5% body weight of the corresponding tank number twice daily. Length and weight measurement were taken weekly. At the end of feeding trial 3 samples were randomly collected, oven dry and prepared for Proximate indices. Results obtained showed that fish fed 30% spirulina inclusion had best performance compared to those fed lower inclusion of spirulina. There was significant difference ($P < 0.05$) in mean weight gain, feed intake and average daily gain between 30% treatment diet and 0% control diet. However, there was no significant difference in Specific growth rate (SGR) and protein efficiency ratio (PER) among treatment and control diets. The following trend in mean weight gain, $T4 > T2 > T3 > T1$, survival rate: $T4 > T3 > T2 > T1$, proximate indices: $T1 > T3 > T4 > T2$ was observed. The supplementation of commercial fish diets with *Spirulina* powder has a positive impact on the growth indices and proximate composition of *Clarias gariepinus*. This study shows that 30% spirulina inclusion diet gave the highest weight gain and survival rate. This implies that *Spirulina* inclusion diets will yield profitable growth in the culture of *Clarias gariepinus*.

Keywords: *Clarias gariepinus*, *Spirulina*, Growth indices; Proximate indices

Introduction

Fisheries and aquaculture make crucial contributions to the world's well-being. As a subsistence produce, fish is a vital resource toward poverty reduction and food security for most poor household across the globe (Cinner *et al.*, 2019). During the pandemic of Covid-19 in 2020, many sectors were affected including the livestock feed industries that provide feed for Aquaculture sector (FAO 2021), unfortunately, the sector provides livelihoods and income, both directly and indirectly, for a significant share of the world's population (Mathiesen, 2012). The aquaculture growth has relied heavily on fishmeal and fish oil. Currently, considerable interest and research have been focused on the developing unicellular organisms such as yeast, molds, bacteria, microalgae and fungi as additives to aquaculture feeds.

"*Spirulina*" is a microorganism which is classified as cyanobacterium. The cell wall of spirulina is composed of protein, carbohydrates and fat and not from indigestible cellulose. Bioavailability of nutrients from spirulina is more than that from other food sources, especially plant food sources. Spirulina has an exceptionally high protein content (on the order of 60-70% of its dry weight), of which 90% is digestible. The use of plant products as protein supplements and sources in fish feeds shows considerable application potential for aquaculture worldwide (FAO, 2010). Spirulina is a multicellular and filamentous blue-algae that has gained considerable popularity in the health food industry and increasable as a protein and vitamin supplement to aquaculture diets (Habib *et al.*, 2008). The biological value of algae protein varies according to the algae species (Becker, 2007). The main objective of the present study was conducted to analyze the nutrient profile such as proximate composition, mineral content and

amino acid profile of species of freshwater algae (*Spirulina platensis*) powder for the purpose of using alternative protein source or additives for aquaculture feeds using Catfish (*Clarias gariepinus*).

Materials and Method

Experimental site

The experiment was conducted at the Benoso farm, Afikpo Experimental Station. Afikpo spans an approximately 164 square kilometers in size. It is located on 6-degree north latitude and 8-degree east longitude. It occupies an area of about 64 square miles (164km²). Afikpo is a hilly area despite occupying a region low in altitude. It is a transitional area between open grassland and tropical forest and has an average annual rainfall of 1955.8mm (195.58cm).

Experiment Fish

Two hundred fingerlings of African catfish *Clarias gariepinus* were collected from the hatchery of the farm at Afikpo in Afikpo North Local Government area of Ebonyi state. the fishes were kept in concrete tanks for one week to acclimate and were fed to satiation with commercial feed prior to feeding trial.

Experimental Feed Treatment

A 40% crude protein feed was prepared using graded levels of Spirulina supplement as crude protein. Feed ingredients were purchased from commercial animal nutrition store in Afikpo market. Experimental diets were prepared using Pearson square method to determine the graded level (0%, 10%, 20% and 30%) of spirulina powder to feed ingredients in order to have four treatment diets (0% = Diet 1, 10% = Diet 2, 20% = Diet 3 and 30% = Diet 4). After which the ingredients were mixed with water to obtain dough for each treatment diet, then the dough was subjected through a 2mm pelleting machine. Thereafter the pellets were sun-dried and then oven-dried at 40°C until a constant weight obtained and packaged in clean container. Proximate composition of experimental diet was done according to standard method by AOAC (1996) as shown in Table 1.

Culture Trial using experimental Diets

The design of this experiment was complete randomized block design, 200 post fingerlings of *Clarias gariepinus* were randomly distributed in 15's into 12 concrete tanks of 1m × 1m × 1m. the tanks were grouped to form 4 treatments in triplicates (T1a – T1c, T2a – T2c, T3a – T3c and T4a – T4c). The experimental fish in treatment tanks were not fed for 48hr pending the commencement of feeding trial. Feeding trial was conducted for 10 weeks and each treatment tank was fed diet with the corresponding number to the tanks at a body weight of 5% twice daily.

At the commencement of feeding trial, the weight (g), Standard length (g) and Total Length of the fish in each tanks were measured with an electronic weighing balance and meter rule respectively. Subsequently, these data were collected weekly between the hours of 6:30am to 9:30am and the percentage of feed fed to the fingerlings were adjusted based on their body weight. Data collected were used to determine Mean Weight Gain (MWG), Mean Length Gain (MLG), Feed Intake (FI) and Survival Rate (SR).

Proximate Composition

2 fishes from each treatment were randomly sampled, killed, oven dried, grounded, stored in poly-bags and labeled according to treatments separately. The samples were analyzed according to standard method by Association of Official Analysis Chemists (AOAC, 2000) to determine, protein content, total lipid, Ash content, moisture content and total carbohydrate.

Data Analysis

Data were presented as mean ± SE. Data were analyzed using one-way analysis of variance (ANOVA), Duncan's multiple range test was used to test significance differences among means. Statistical significance was accepted at $P < 0.05$ level.

Table 1: Proximate Analysis of the fed Diets

Parameters	T1	T2	T3	T4
N	8.24±0.50	7.71±0.70	7.96±0.80	8.01±0.48
CP	40.19±0.40	39.13±1.20	39.95±1.80	41.02±1.48
MC	16.38±1.30	17.96±0.60	18.14±0.98	16.68±0.52
ASH	13.34±0.86	11.84±0.20	12.67±0.83	13.13±0.61
CF	10.93±0.95	12.95±0.65	11.04±0.89	10.81±0.82
LIPID	17.41±0.64	19.11±0.96	18.09±1.10	19.17±0.78
CHO	52.48±2.60	60.13±1.40	57.29±2.80	59.87±3.49

Results and Discussion

The content of the experimental diets in table 1, is a reflection of the nutritive value of the material present. The proximate composition of treatment diets revealed that diet containing graded levels of spirulina were not significantly different from the control diet with 0% spirulina. This implies that if these nutrients are adequately utilized, they could improve the wellbeing of the fish. According to Kerema and Green (2006), 10 – 20% lipid in fish diets gives optimal growth rate without producing excessive fatty acid. This level of lipid falls within the range of values for lipid in this study. The result of weight gains and length increase of this study in table 2, is an indication that inclusion of Spirulina in the diet were nutritionally adequate to support growth. However, T4 with 30% inclusion of spirulina had the best growth performance with regard to weight gain (WG), Feed conversion ratio (FCR), Average Daily gain (ADWG), significantly different from Control diet (T1). This findings were in line with Palmegiano *et al.*, (2005), who observed sturgeon fed diet containing 50% spirulina inclusion had best growth performance. This research is also in line with Seval *et al.*, (2010), who reported inclusion of spirulina in the diet of *Clarias gariepinus* gave better growth than control diet. However, there was no significant difference among tested diet for Specific growth rate (SGR) and Protein Efficiency Ratio (PER) in this study which is not in line with James *et al.*, (2006) who reported increased in specific growth rate (SGR) as inclusion level of spirulina increase in the diets.

Survival rate of this study showed that there was highest mortality of 33%, 47%, 60% for diet T4, T3 and T2 compared to the T1 (control) 73%. This observed result is in line with the report of Seval *et al* (2010), that white shrimp larvae fed spirulina supplemented diets had lower mortality when compared to control diet with no spirulina inclusion. The proximate composition of experimental fish shows relative difference from fish fed control diet and treatments. This is in line with Kerema *et al* (2006), suggesting that fish growth was not due to increase in weight only but is also associated with synthesis of Tissue protein. The crude protein range observed in this study was 24 – 29%, which is higher than Shabana and Arabi (2012), who reported 22% protein.

Conclusion and Recommendation

Fish feed is the major cost of fish production in Aquaculture industries, hence there is need for research into other alternative sources of fish feed ingredient in order to reduce cost of fish production consequent by fish feed. It was in this regard that this research was conducted to ascertain the growth indices and proximate profile of *Clarias gariepinus* fed with Spirulina supplemented diets. The present study showed that fish Diets supplemented with Spirulina powder had a positive impact on the growth indices and proximate profile of *Clarias gariepinus*. However, there is need for more research on the metabolic processes in *Clarias gariepinus* when fed diet containing Spirulina. Based on the findings from this study, it is therefore recommended that more research should be conducted in order to establish the potentials of supplement fish diet with *Spirulina platensis* powder and also replacement of fish meal partially as source of protein.

Table 2: Growth Performance of African Catfish Fed With Diet Containing Spirulina for 10 Weeks

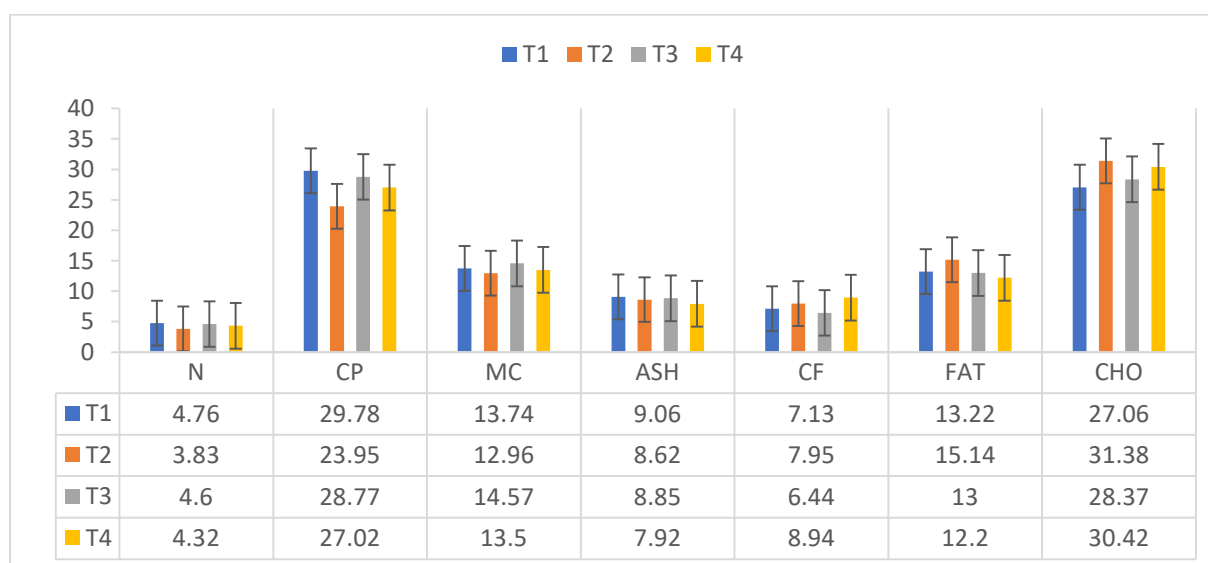
Parameters	T1	T2	T3	T4
Initial	2.53±0.66	2.67±0.46	2.73±0.37	2.80±0.08
Final	28.33±1.21 ^b	44.07±6.80 ^{ab}	36.33±3.20 ^{ab}	50.00±4.30 ^a
MWG	25.80±0.55 ^b	41.40±6.34 ^{ab}	33.60±2.83 ^{ab}	47.20±4.22 ^a
Feed Intake	27.04±1.18 ^b	42.00±6.48 ^{ab}	34.65±3.06 ^{ab}	47.64±4.09 ^a
ADWG	0.43±0.01 ^b	0.69±0.11 ^{ab}	0.56±0.05 ^{ab}	0.79±0.07 ^a
SGR	4.09±0.38 ^a	4.68±0.03 ^a	4.32±0.08 ^a	4.80±0.10 ^a
PER	2.39±0.06 ^a	2.47±0.01 ^a	2.43±0.01 ^a	2.48±0.01 ^a

Means with different superscript along same row are significantly different (p<0.05)

Table 3: The Survival Rate of the Fishes Fed With the Diets Containing Spirulina

Parameters	T1	T2	T3	T4
Initial	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00
Final	26.70±1.00 ^d	40.00±2.00 ^c	53.00±4.00 ^b	67.00±3.00 ^a
Mortality	73.30±1.00 ^a	60.00±2.00 ^b	47.00±4.00 ^c	33.00±3.00 ^d

Means with different superscript along same row are significantly different (p<0.05)

**Figure 1: Proximate Analysis of *Clarias gariepinus* among Treatments**

References

- Becker, E.W. (2007). Micro-algae as a source of protein. *Biotechnology Advance*; 25: 207-10.
- FAO. (2010). Fish Stat Plus-Universal software for fishery statistical time series Comments/ inquiries Site map Logine-Bulletin© FAO, 2010 National Aquaculture Sector Overview India.
- George, W. (2011). Technology +Training= Capacity Building, *the Global Aquaculture Advocate.*; 14: 1.
- Goytortua-Bores, E., Civera-Cerecedo, R., Rocha-Meza, S. and Green-Yee, A.(2006). Partial replacement of red crab (*Pleuroncodes planipes*) meal for fishmeal in practical diets for the white shrimp *Litopenaeus vannamei*. Effects on growth and *invivo* digestibility. *Aquaculture*; 256: 414-422.

- Hardy, R.W. (2001). Urban legends and fish nutrition, Part 2. *Aquacult Mag.*; 27: 57-60.
- Jaime-Ceballos, B., Villarreal, H., Garcia, T., Pérez –Jar, L. and Alfonso, E. (2005). Effect of *Spirulina platensis* meal as feed additive on growth, survival and development in *Litopenaeus schmitti* shrimp larvae. *Rev. Invest. Mar.* 26(3): 235-241.
- James, R., Sampath, K., Thangarathinam, R. and Vasudevan I. (2006). Effect of dietary spirulina level on growth, fertility, coloration and leucocyte count in red swordtail, *Xiphophorus helleri*. *The Israeli Journal of Aquaculture – Bamidgeh*, 58(2): 97-104.
- Mathiesen, A. M. (2012). The state of world fisheries and aquaculture. FAO Fisheries and Aquaculture Department, Rome.
- Nandeesh, M.C., Gangadhara, B., Manissery, J.K. and Venkataraman, L.V. (2001). *Bioresour. Technol.*, 80:117-120.
- Naylor, R. L., Goldburg, R. J., Primavera, J. H., Kautsky, N. and Beveridge, M. C. M. Clay J, et al. (2000). Effect of aquaculture on world fish supplies. *Nature*. 405: 1017- 1024.
- Naylor, R. L., Hardy, R. W., Bureau, D. P., Chiu, A., Elliott, M., Farrell, A. P., Forster, I, et al. (2009). Feeding aquaculture in an era of finite resources. *Proceedings of the National Academy of Sciences USA.*: 8; 15103-15110.
- Palmeigiano G. B., Agradi E., Forneris G., Gai F., Gasco L., Rigamonti E., Sicuro B. and I. Zoccarato, (2005). Spirulina as a nutrient source in diets for growing sturgeon (*Acipenser baeri*). *Aquac. Res.*, 36:188-195.
- Rogatto, G. P. Machado de Oliveira, C. A. dos Santos, J. W. Manchado, F. B. Nakamura, F. Y., de Moraes, C. Zagatto, A. M. Faria, M. C. Afonso, M. and Rostom de Mello, M. A. (2004). Influence of spirulina intake on metabolism of exercised rats. *Rev Bras Med Esporte*, 10(4): 264-268
- Seval, D., Hatice, U., Ismihan, K. and Orhan, A. (2010). Effect of Dietary Supplementation of Different Rates of Spirulina (*Spirulina platensis*) on Growth and Feed Conversion in Guppy (*Poecilia reticulata* Peters, 1860). *Journal of Animal and Veterinary Advances* 9 (9), 1395-1399.
- Shabana, K. A. and Arabi, M. S. (2012). Spirulina – An Overview. *International Journal of Pharmacy and Pharmaceutical Sciences*; (4)3, pp 34. ISSN- 0975-1491
- Tacon, A.G.J. and Barg, U.C. (1998). Major challenges to feed development for marine and diadromous finfish and crustacean species. In: De Silva SS. *Tropical Mariculture*. Academic Press, San Diego, CA, USA. 171-208.
- Tacon, A.G.J. and Metian, M. (2008). Global overview on the use of fish meal and fish oil in industrially compounded aqua feeds: trends and future prospects. *Aquaculture*; 285: 146-158.

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Preference of Fish Consumption among Residents of Matazu Metropolis, Katsina State, Nigeria

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Abstract

This study was conducted to examine the consumption preference of five (5) different fish types in Matazu metropolis using a total of one hundred and twenty (120) structured questionnaires. The questionnaires covered information on demographic data of respondents, rate of fish consumption and type of fish consumed between September and December 2020. The data were analysed using descriptive statistics. The result showed that respondents whose ages fall between (15–24 years) had the highest representation of 49 respondents (40.84%). Majority (55.83%) of the consumers were married and have attended secondary school (35%), most of the respondents responded positively in terms of fish consumption (77.5%) while 27 with negative response (22.5%). In addition, most of the respondents were male (58.34%), 50 respondents (41.66%) were females, while 26 respondents (21.6%) mode of consumption of fish species were twice weekly. However, 65 respondents (54.1%) preferred to consume all the species. Tilapia species 14 respondents (11.6%), *Clarias* species and *Gymnarchus niloticus*, with 4 (3.3%) and 4 (3.3%) respectively, more over *Bagrus bayad* had 6 (5%). The study revealed the availability of the species, the cost of the fish, freshness, method of processing and taste of the fish affects consumer preference, while constraints to fish demands are low level of consumer income, inadequate fish markets and poor availability of fish farmers.

Keywords: Fish Consumption, Preference, Choice, Fish Species, and Matazu Metropolis

Introduction

Fish is a nutritious animal protein and is believed to be a comparatively cheaper and available source of animal protein in most countries around the world (Martins, 2015), providing essential fatty acids, among other micronutrients. These reasons have therefore promoted fish as an important component of a healthy meal (Birch *et al.*, 2012). Some previous studies have highlighted the health and nutritional benefits associated with fish consumption such as increased intelligence and cognitive development in children, reduced risks of cardiovascular disorders, reduced risks of high blood pressure and reduced risks of various forms of cancers (Can *et al.*, 2015; Kris-Etherton, 2003). Demand for fish products was reported to double as other animal protein sources become more costly due to pressure on demand by the ever increasing population (Ojo and Fagbenro, 2004). Fish being a cheap and most affordable animal protein to the common man provides up to 40% of animal protein consumed by an average Nigerian (Fagbenro, 2004). According to Magawata and Shina (2013), fish consumption in Nigeria is only higher in the southern part of the country compared to the northern parts of Nigeria. This could be due to limited uneven distribution of natural fish as a result of rainfall pattern, number of water bodies, fishing techniques, preservation, and general acceptability of fish among others (Ibrahim *et al.*, 2013). Fish supplied in Nigeria is either through capture fisheries, fish farming or by importation (Anene *et al.*, 2010). According to Akpinar, *et al.* (2009), found out that variety, supply channel, price and production method were effective and significant in purchasing preference of the consumer. According to Olsen *et al.* (2009), Consumers' preference study provides better relationship with actual purchase or consumption. Preference is considered to be a major factor influencing general food consumption behaviour (Myriand *et al.*, 2000). To the best of our knowledge, no research on fish consumption patterns and consumer preference was carried out in Matazu metropolis. This study therefore examined the determinants of these preferences with a view to developing a guide in the area of fish processing policy in Katsina state and Nigeria at large.

Methodology

Study area: the survey was conducted in Matazu metropolis of Katsina state on Latitude: 12° 23' 33" N, Longitude: 7° 66' 67" E, Altitude 612m. It has an area of 503 km² with a Population range between 16,000 and 40,000. The average annual rainfall is 582 mm (TGAOE, 2013). The study was carried out using a total of 120 structural questionnaires administered to respondents. Six wards were randomly selected in the metropolis and 20 questionnaires were administered to each by random selection of respondents.

Data collection and analysis: The data obtained from this study was analysed using simple descriptive statistics and Percentage.

Results

Details bio data of the respondents were presented in (Table 1). While the rate of fish consumption was presented in (Table 2) which showed that (77.5%) consumed fish while only (22.5%) are not interested in consuming fish. Table 3: Showed the type and preferred fish by the respondents in Matazu metropolis, which indicated that about (54.1%) consuming all the types of fish asked, while some showed selectivity in fish consumption

Table 1. Bio data of the respondents

Parameters	Respondent	Percentage (%)	Age
16-25	49	40.84	
26-35	30	25	
36-45	23	19.16	
46 and above	18	15	
Sex			
Male	70	58.34	
Female	50	41.66	
Marital Status			
Single	48	40	
Married	67	55.83	
Widow	4	3.34	
Age Divorced	1	0.83	
Educational Status			
Quran school	39	32.5	
Primary school	22	18.34	
Secondary school	42	35	
Tertiary Institution	17	14.16	

Table 2: Rate of fish consumption in the study area

Parameter	Respondents	Percentage (%)
Do you consume fish?		
Yes	93	77.5
No	27	22.5
How frequency does you Consume fish		
Daily	20	16.6
Twice weekly	26	21.6
Weekly	15	12.5
Fort nightly	14	5.8
Monthly	25	20.8

Table 3: Type of fish consumed in the study area

Parameter	Respondent	Percentage (%)
<i>Tilapia</i>	14	11.6
<i>Bagrus bayad</i>	6	5
<i>Clarias gariepinus</i>	4	3.3
<i>Mormyrus rum</i>	0	0
<i>Gymnarchus</i>	4	3.3
Consuming all the species	65	54.1

Discussion

The factors affecting consumers' preference are numerous ranging from production to consumption. The major problems include income, availability of the product, cheapness compared to close substitute, nutritive value etc. Availability of different species of fish in the market can affect the rate at which they are consumed. If the fish is available in the market definitely they will be consumed. Fish are highly diversified, there are many species of edible fish and each

species differ significantly in terms of taste, price, production volume and location. Musa and Ala (2011). To engage in fish farming, an analysis of consumers' preferences for each species of fish is essential for successful fish farming Musa and Ala (2011). Sex is an important factor that has significant influence on the fish preference and consumption pattern in Matazu local Government area of Katsina state. This is because women patronize the market and select good quality varieties of protein rich food items, subsequently increase their consumption for them (Amao and Ayantoye, 2014). The study revealed slightly higher proportion of male fish consumers 70(58.34%) than female fish consumers 50(41.66%). These findings indicated that 93 (77.5%) of the respondents consumed fish while 27(22.5%) do not consumed fish.

Therefore there is a tendency for more purchases of fish and increased consumption by households headed by married people than singles due to an expansion in family size and greater responsibilities in terms of expenditures on food items(Amao and Ayantoye, 2014). There is a tendency for the age of the household head to affect the preference and consumption pattern of a household because it can determine to an extent the type and quality of nutrition of the household. This study showed that young people within the age bracket of 15-24 consumed more fish than those in other age groups 40.84%. Education changes taste over time and usually affect consumption pattern, preference for fish species and nutrition of a household this is because consumers become aware of the nutritional value of protein rich food items like beef, eggs and fish and subsequently enhance their consumption Jimoh *et al.*, (2013). Households make choice out of various food items available at their disposal and this in turn determines the level and extent to which consumption would be based. Therefore, an analysis of consumer preference for type of fish is important, and this may be useful for fish production, planning, trade, distribution and marketing. The result of this work is in line with the finding of Musa and Ala (2011) who reported that Tilapia and Clarias are most preferred fish species for consumers in Nigeria.

Conclusion

This study assessed fish consumers' preferences, quantities and species of fish frequently consumed and probable factors affecting fish consumption in the area. *Tilapia*, *Bagrus bayad*, and *Clarias gariepinus*, were mostly preferred fish species in the study area. The factors affecting consumption of the identified fish species were noted to be price, convenience, availability, accessibility and healthy concerns. Understanding typical diet in populations with a high prevalence of under nutrition will help to develop strategies and appropriate interventions to improve the nutritional status. Therefore, further data on commonly consumed fish species, preference, seasonality and intra-household distribution are needed as well as consumption patterns of other food items. The people should be encouraged and trained on important of aquaculture and on possible reasons why nutrition is important.

Reference

- Adeniyi OR, Omitoyin SA and OO Ojo (2012); Socio-economic determinants of Consumption pattern of fish among households in Ibadan North Local Government Area of Oyo State, Nigeria. AJFAND Online.African Scholarly Scientist Communication Trust 12(5) 6538.
- Akinosho G. A (2013).Evaluation of consumers' preference for fresh and frozen fish products in Ibadan Metropolis, Nigeria.Federal College of Animal Health and Production Technology, PMB 5029, Ibadan .patnsukjournal.net/currentissue 9 (1): 13-20
- Akpınar M.G, Dagistan E, Mazlum Y, Gul M, Kol Band Yilmaz Y (2009); Determining Household preferences for fish consumption in Turkey. *Journal of Animal Veterinary Advances* 8(11)2215-2222.
- Amao J.O. and Ayantoye, K. (2014).Consumer Preference and Consumption Pattern for Selected Forms of Fish in Oyo State, Nigeria. *International Journal of Science, Environment And Technology*, 3 (3) : 841 – 860
- Anene A, Ezeh CI, Oputa CO. Resources use and efficiency of artisanal Fishing in Oguta, Imo State, Nigeria. *J. Dev. Agric. Econ.* 2010;2:94-99.
- Atanda AN. Fish species diversification in agriculture for the success of the agriculture transformation agenda. The Role of Tilapia Production; FISON Annual Public Lecture. 2012;21.
- Birch D, Lawley M, Hamblin D. Drivers and barriers to seafood consumption in Australia. *Journal of Consumer Marketing*. 2012; 29(1):64-73.
- Can MF, Günlü A, Can HY. Fish consumption preferences and factors influencing it. *Food Science and Technology (Campinas)*. 2015; 35(2):339-346.
- Dauda AB, Yakubu SO. Fish consumption pattern and knowledge of Fish farming among inhabitants of Dutsin-Ma LGA, Katsina State. *Niger. J. Fish.* 2013;10: 586-594.
- Esilaba FA, Moturi WN, Mokua MA. Urban consumers' fish preferences and the determinants influencing fish selection and consumption: Case study of Nakuru, Kenya. *International Journal of Fisheries and Aquatic Studies*. 2017; 5(3):356-360.

- Fagbenro O. A., Akinbulumo M. A. and Ojo S. O. (2004). Aquaculture in Nigeria –History, Status and Prospects. World Aquaculture 35 (2) pp 1-6.
- FAO, 1996. Yearbook of Fishery Statistics. FAO Annual Publication, Rome, pp: 64. FAO. (2009 a). Calculated from food balance sheets. [Online] FAOSTAT (Updated: 18 December 2009) Available at: <http://faostat.fao.org/site/368/DesktopDefault.aspx?PageID=368#ancor>.
- FAO. (2009 b). Low - income food - deficit countries 2009. [Online] FAO country profiles. Available at: <http://www.fao.org/countryprofiles/lifdc>.
- Fayyaz, A. Nauman, Conrado M. Gempesaw, J. Richard Bacon (1995); Consumer Choice for Fresh Fish: Factors Affecting Purchase Decisions.
- Gomna, A., Rana, K. (2007). Inter-household and intra-household patterns of fish and meat consumption in fishing communities in two states in Nigeria. *British Journal of Nutrition*, 97(1), 145 - 152.
- Ibrahim ShehuJega. Ibrahim Magawata, Joseph KayodeIpinjolu and MuawiyahJibir (2013). Quality Evaluation of Kilishi Processed Bony Tongue (*Heterotis niloticus*, Cuvier) Under Different Storage Media. *International Journal of Agriculture and Food Science Technology*. ISSN 2249-3050 4(2) 83 – 93.
- Jimoh W. A, Popoola M .A, Ibrahim G. A., Ayelaja A. A., Ayanwale A. O. S and Kwarazuka N., (2010). The contribution of fish intake, aquaculture, and small-scale fisheries to improving nutrition: A literature review. The World Fish Center Working Paper No.2106. The World Fish Center, Penang, Malaysia. 51 p.
- Kris-Etherton P.M. Omega-3 fatty acids and cardiovascular disease new recommendations from the American Heart Association. *Arteriosclerosis, thrombosis, and vascular biology*, 2003, 151-152.
- Magawata, I. and AASHina. (2013). Effect of Spice Treatment on the Quality of Solar Dried African Catfish, of *Clarias gariepinus* (Burchell, 1822) in Sokoto, Nigeria. *Food Science and Quality Management Journal* ISSN 2224-6088 (Paper) ISSN 2225-0557 (Online) Vol. 19, 7 – 14.
- Martins Library (2015). Fish Consumption in Nigeria: Implications for Fishery Development Policies, [www.http://martinslibrary.blogspot.com.ng](http://martinslibrary.blogspot.com.ng). Retrieved on 26th, November, 2015
- Mugaonkar P.H, Ananthan P S, Samal S S and Debnath B (2011); A Study on Consumer Behaviour at Organized Fish Retail Outlet. *Agricultural Economics Research Review* 24: 133-140.
- Musa D and Ala, A.L. (2011) Fish Preference among Residents of Sokoto Metropolis, Sokoto state, Nigeria *Pakistan Journal of Social Sciences* Volume: 8:3 132-134 The Greatest App on Earth: Hadejia Town <http://www.atlasbycollins.com/> retrieved on 29th sept, 2013.
- Myrland O., Trondsen T., Johnston R. S. and Lund E. (2000). Determinants of seafood consumption in Norway: lifestyle, revealed preferences, and barriers to consumption. *Food Quality and Preference* 11, 169-188.
- Olsen, S. O., Prebensen, N., and Larsen, T. A. (2009). Including ambivalence as a basis for benefit segmentation: A study of convenience food in Norway. *European Journal of Marketing*, 43(5/6), 763-783.
- Pieniak Z., Verbeke W., Scholderer J., Brunso K. and Olsen S. O. (2008). Impact of consumers' health beliefs, health involvement and risk perception on fish consumption: A study in five European countries. *British Food Journal* 110(9), 898 – 915.
- Tontisirin, K., Nantel, G., Bhattacharjee, L. (2002). Food-based strategies to meet the challenges of micronutrient malnutrition in the developing world. *Proceedings of the Nutrition Society*, 6a1(2), 243 - 250.

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Effects of Different Processing Methods on Proximate and Aflatoxin Compositions of Groundnuts (*Arachis hypogaea*) as Fish Feed Ingredient

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Abstracts

The ingredients used in formulating fish feeds have been linked to some of the fish farm diseases coming from fish feed. Based on this, groundnut which is one of the major sources of protein in fish feed ingredients used in Nigeria was considered for this study. Five (5 kg) of groundnut seed were purchased and divided into four equal parts. Each was processed by roasting, toasting, solid state fermentation (SSF), sprouting in triplicates. The SSF and sprouting processing were carried out for seven days in a dark room and pH with Temperature were recorded twice daily. The ingredients processed using different methods and the unprocessed were tested for proximate and aflatoxin B1 and B2 compositions. The results of the study showed that the unprocessed was toasted and roasted at 120°C at a time interval of 32-45 minutes. The pH range of 4.5 – 6.0 were recorded for groundnut during SSF while 5.0 to 6.0 for sprouting. The proximate compositions varied with the processing methods. The lowest Aflatoxin B1 and B1 of 0.48mg/100g and 0.45mg/100g were recorded in toasted groundnut. Based on this toasting method is recommended for processing groundnut to increase nutrient compositions and reduce Aflatoxin.

Key words: Groundnut, Processing, Proximate, Aflatoxin

Introduction

The high demand for fish can be linked to the good nutritional balance of protein, vitamins and minerals with low fat of 10% calories and an excellent source of omega-3 fatty acids present in the products. The total fish demand in Nigeria for 2015 was 2.66 million metric tons out of which only 0.73 million metric tonnes was produced domestically (Sogbesan, 2014). There is also the risk of introducing moulds and mycotoxins into the feeds through unhygienic feed mill where the feedstuffs are milled before production processes (Banu and Muthumary, 2008). Moulds and mycotoxins contamination reduce feed quality and predispose fishes to incidences of mycotoxicoses when consumed. Fish are sensitive to mycotoxins causing reduction in feed intake and utilization which could lead to poor growth and development. The aquaculture production can be increased by production of mycotoxin free feeds because Döll *et al.* (2010) and Hooft *et al.* (2011) have reported negative growth in fish feed mycotoxin diets. The presence of mycotoxins in aquafeeds produced locally has also caused immeasurable diseases leading to high mortality in fish production, reduction in yield and also resulting to immeasurable human health challenges. Efforts by farmers to boost Agricultural productions were concentrated on yield without considering risk involved in the poor farming practices and improper farm produce handling (Ahmed, 2014). More also, evidence from earlier study reported by Ogimlela and Mukhtar (2009) had shown that Nigeria farm produce failed the test of quality and safety in the international markets. This has made most international industries that were looking into direction of Nigeria's farm produces as raw materials are changing their direction to other nations such as Malaysia (Oladele, 2014). The main focus of this study is to see the effect of different processing methods in reducing aflatoxin and improving nutrients in groundnut which is a renowned plant protein source in Nigerian aquaculture feed.

Materials and Methods

Experimental location

Adamawa state is located within the climate of Northern Guinea Savannah Zone and lies between latitude 8° and 11° N and Longitude 11.5° and 13°E and climate is tropical with two distinct seasons which are dry and wet seasons. The research was carried out at the Department of Fisheries, Moddibo Adama University of Technology wet laboratory, Yola in Adamawa state.

Experimental design and Experimental set-up

This is a factorial experiment arranged in completely randomized design using four different processing methods and replicated thrice. The processing methods were Toasting, Roasting, Solid fermentation and Sprouting. The unprocessed (raw) ingredients acted as the control.

Experimental procedures

Processing methods

One kg of each of groundnut was purchased from feedstuff market at Jambutu. The ingredients were divided into five equal portions and each was processed by toasting, roasting, solid state fermentation and sprouting following the procedures of Sogbesan (2012) and (2014).

Statistical Analysis

All data collected was subjected to One-way analysis of variance (ANOVA). Standard deviation was calculated to identify the range of means and error respectively. Least Significance difference (LSD) was used to determine the level of significance at the probability of 5% among treatments using SPSS 16.0 and Graphpad Instat (DATASET 1) Statistical Packages for Windows 2000.

Results and Discussion.

The proximate compositions of the raw and processed groundnut seeds are presented on table 1. The crude proteins of the processed ingredients were higher than those of the raw.

Table 1. Proximate Composition of unprocessed and Processed Groundnut

Treatments	Dry matter %	Crude protein %	Crude lipid %	Crude fibre %	Ash %	Nitrogen free extract %	Gross Energy Kcal/g
Raw	87.92±5.67 ^b	27.83±2.40 ^c	46.53±2.33 ^a	6.85±0.51 ^a	4.25±0.03 ^a	1.75±0.01 ^b	583.49±20.01 ^b
Toasted	89.35±3.23 ^a	28.85±1.67 ^{ab}	47.63±2.65 ^a	6.25±0.33 ^a	4.20±0.02 ^a	2.72±0.05 ^b	602.98±20.06 ^a
Roasted	88.50±2.88 ^{ab}	28.43±1.69 ^{bc}	44.15±2.34 ^b	5.96±0.13 ^a	4.50±0.03 ^a	5.46±0.02 ^b	579.97±20.27 ^b
Fermented	89.20±2.43 ^a	30.18±2.30 ^a	39.58±2.01 ^c	3.75±0.22 ^b	4.21±0.06 ^a	11.75±0.17 ^a	576.58±21.04 ^b
Sprouted	89.20±2.33 ^a	29.78±1.08 ^a	32.53±2.00 ^d	5.96±0.18 ^a	5.00±0.09 ^a	15.94±0.13 ^a	523.57±20.64 ^c

Means on the same column with different superscripts are significantly different (p<0.05)

Tables 2 presented the Aflatoxin B1 and B2 for unprocessed and processed groundnut and from the table, it can be deduced that toasted ingredients are significantly different (p<0.05) with lower values compared to the unprocessed and other processed methods for Aflatoxin B1 and B2

Table 2 Aflatoxins Composition of Unprocessed and Processed Groundnuts

Treatment	AF.B1	AF.B2
Raw	2.12±0.01 ^c	1.34±0.01 ^c
Roasted	3.16±0.03 ^b	2.42±0.02 ^a
Toasted	0.48±0.02 ^d	0.45±0.03 ^e
Fermented	3.72±0.01 ^a	0.97±0.01 ^d
Sprouted	3.12±0.01 ^b	1.85±0.03 ^b

Means on the same column with different superscripts are significantly different (p<0.05)

Discussion

The proximate composition of these ingredients varied with the processing method in comparable to the raw. In his report Sogbesan (2011) on the processing of Mucuna reported that Mucuna seed processed reported better crude protein, ash and lower fibre compared with the raw. The presence of Aflatoxin B1 and B2 in all the ingredients despite their different processing method is an indication that this mycotoxin cannot be fully eliminated from an ingredient with heat or water treatments. Although, toasting method proves better in reducing their quantities. Processing technology has a direct impact on feed quality in terms of physical properties and nutrient digestibility. Aflatoxins are fluorescent compound, they are chemically classified as difurocoumarolactones and their biosynthesis by the producing fungi is via polyketide pathway Akande *et al.*, 2006).

References

- Ahmed, H.J. (2014). Determination of Aflatoxins in some local materials and their products. M. Tech Thesis. Department of Food Science and Technology, Modibbo Adama University of Technology, Yola. 67p.
- Akande, K.E., Abubakar, M.M. Adegbola, T.A. and Bogoro, S.E. (2006). Nutritional and health implications of mycotoxins in animal feeds: A review. *Pakistan Journal of Nutrition*, 5:398-403.
- Banu, N. and Muthumary, J. (2008). Screening of commercial feed samples for the presence of multimycotoxins. *Indian Journal of Science and Technology*, 1(4):23-55
- Döll, S., Baardsen, G., Koppe, W., Stubhaug, I. and Dänicke, S. (2010). Effects of increasing concentrations of the mycotoxins deoxynivalenol, zearalenone or ochratoxin A in diets for Atlantic salmon (*Salmo salar*) on growth performance and health. The 14th *International Symposium on Fish Nutrition and Feeding*, Qingdao, China, p. 120.
- Hooft, J.M., Elmor, A.H.I., Encarnação, and Bureau, D.P.(2011). Rainbow trout (*Oncorhynchus mykiss*) is extremely sensitive to the feed-borne *Fusarium* mycotoxin deoxynivalenol(DON). *Aquaculture*, 311: 224–232.
- Ogimela, T. and Mukhtar, S. (2009). Issues in Agriculture and Nigeria farm produce export: The role of women in Agriculture. *Humanity and Social Science Journal*, 4(1):19-30.
- Oladele, D. (2014). The effects of aflatoxins on animals’ Partnership for aflatoxin control in Africa (Meridian Institute, Washington, DC), Aflatoxin partnership *Newsletter*, vol. II (Accessed, Feb 2014),4.
- Sogbesan, O.A. (2011). Economics of production, processing techniques and utilization of maggot meal and *Mucuna pruriens* in the diet of *Heterobranchus longifilis*. *Competitive Agricultural Research Grant Second Quarter Report*. 50p
- Sogbesan O.A (2014). *Non-conventional Animal protein feedstuffs for the culture of catfish*. Ibadan Press, Ibadan. 99p

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Growth and Cost Benefits of *Clarias gariepinus* (Burchell, 1822) Fingerlings Fed Boiled Chicken Intestine Meal Diets

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Abstract

Hike in the price of fishmeal which is the major source of animal protein in fish diet necessitated the need for alternative sources. Chicken intestine were collected fresh and boiled. Five isonitrogenous diets containing 40% crude protein were formulated using boiled chicken intestine meal to substitute for fish meal at 0%, 25%, 50%, 75% and 100%, and coded as T1, T2, T3, T4 and T5 respectively in a factorial design arranged in completely randomized pattern. 150 fingerlings of *Clarias gariepinus* of mean weight, 4.31 ± 0.54 g and mean length, 7.20 ± 0.36 cm were used for the experiment and ten (10) fingerlings were assigned into 15 plastic bowls each and at 5% body weight for 84 days and weekly weight were monitored. Data generated were treated with descriptive statistics and ANOVA. The highest mean weight gained 10.81g/fish was recorded in fish fed T4 and least was from T1 fed fish. There was significant different ($p < 0.05$) in mean weight gain within the treatments. T3 and T4 had the best feed conversion ratio. The best protein efficiency ratio (PER) with values 0.11g was recorded in T4 while T1 recorded the worst PER and these are significantly different ($p < 0.05$). The highest survival rate was recorded in T3. The cost benefit ratio shows a reduction in production as the inclusion levels of boiled chicken intestine increased. Based on the findings from this study, inclusion of boiled chicken intestine meal could be substituted in the diets of *Clarias gariepinus* up to 100% inclusion for sustainable aquaculture production.

Keywords: Growth, Cost benefits, Chicken intestine meal, fish meal, *Clarias gariepinus*

Introduction

Aquaculture has the potential to fill the gap between stable fisheries production and increasing demand (Naylor *et al.*, 2000). In order to have a good production, it is important to have knowledge on how and where to get the ingredients, the price, the availability, the type and the amount of the ingredients to be used for the feed production, and this should not compromise the nutrient quality required (as in fish meal) but should be able to replace the fish meal and capable of raising fish to table size at a lower cost of production and reduced culture time (Sogbesan, 2014). According to Akand *et al.* (1991) the development of quality fish feed is a key to the success in the culture of commercial fish.

Fish production is becoming a very important source of valuable animal protein food and the major fishmeal for aquaculture. Globally, the supply of fishmeal is not growing and the price is often high, so the replacement of fishmeal with cheaper protein sources is needed (Sogbesan, 2014). Therefore, efforts have been made to find alternative protein sources of good quality which are less expensive and readily available as substitutes for fish meal component in fish diets. Chicken viscera are among such protein sources with the potential to replace fishmeal in fish diet. It is a very cheap and readily available source of high quality animal protein which is considered as waste in the poultry industry (Omitoyin and Faturoti, 2000). Hence this study examined effect of replacing fish meal with boiled chicken viscera meal on the growth and cost benefits of *Clarias gariepinus*.

Materials and Methods

The experiment was conducted in research fish farm of Fisheries Department, Modibbo Adama University, Yola in Girei Local Government of Adamawa State. The experiment lasted for the period of eighty-four (84) days. A factorial experiment arranged in a completely randomized design was used for the experiment. A flow through system in fish farm of Modibbo Adama University, Yola, was used for the experiment. The experimental set up consisted of fifteen (15) bowls grouped into five (5) treatments with three (3) replicates each. One hundred and fifty (150) fingerlings of *Clarias gariepinus* were used for the experiment and were obtained from the Fish farm of fisheries Department, Modibbo Adama University of Technology, Yola. The fish were acclimatized for five days during which they were fed with control diet.

Collection and processing of chicken's intestine

The chicken's intestine used for this experiment was collected from Jimeta modern market and Yola market in Yola North and South Local Governments of Adamawa State respectively at their chicken slaughter unit. After the collection of the chicken intestine, it was thoroughly washed with water to remove the fecal content as much as possible. The cleaned chicken intestine was then boiled using pressure cooker for 15 minutes at 100°C then dried and milled into powdered form using pestle and mortar. Other ingredients that were used for the feed formulation include maize, soybean, groundnut cake and maize bran and were all purchased. Also, the fixed ingredients (starch, calcium phosphate, lysine, salt, methionine, vitamin and mineral premixes and vitamin C) were obtained in the store where they are being sold.

Experimental Diets and feeding

Five (5) isonitrogenous diets were formulated which contained 40 percent crude protein (CP). Chicken intestine and fish meal were used major source of animal protein in the diet, in which boiled chicken intestine was used to substitute fish meal at different inclusion levels due to its proximate compositions as shown in Table 1.0. The ingredients were then mixed, milled and was produced into pellets and then stored in a clean, cool dry place (Bolorunduro, 2002). The *Clarias gariepinus* fingerlings obtained for the experiment were stocked in the 15 plastic bowls and a total number of 10 fingerlings were randomly assigned into each plastic bowl. Fingerlings of *C. gariepinus* were acclimatized to experimental conditions for five (5) days, during which the fish were fed with control diet.

After acclimatization, the initial body weights of the fish were taken using electronic compact scale weighing balance before stocking. Subsequently, the weights of the fish in each bowl were measured on weekly basis throughout the experiment and used to adjust the quantity of feed fed at 5% body weight twice a day by 8:00am and 5:00pm daily at 5% body weight. Water parameters were monitored every week and recorded which include Temperature, Dissolved oxygen, Hydrogen-Ion- Concentration (pH), Alkalinity, and Ammonia, using mercury in bulb thermometer, Dissolved Oxygen kit and pH meter. The Alkalinity and Ammonia were determined using APHA (1990). Growth Performance, Feed Utilization and Cost Benefit indices were determined following Sogbesan (2012) methods. Data were analysed statistically using descriptive statistic and One-way analysis of variance.

Results and Discussion

The result of the proximate analysis composition of the experimental diet of all the treatment is presented in table 3. The result of the analysis showed that T 4 had the highest protein content of 40.09%, while the lowest protein content of 39.67% CP was recorded in T1. These were not significantly different ($p > 0.05$). T5 recorded the highest CL of 13.04% and lowest CL was recorded in T1. Highest Ash of 11.93% was recorded in T1 while the lowest Ash of 10.06% was in T3.

Table 3 shows the growth responses of *Clarias gariepinus* fingerlings fed experimental diets 0%, 25%, 50%, 70% and 100% respectively. The initial weight of the experimental diets fish varies across the five (5) treatments and it depended on the initial weight of the experimental fish of each treatment. The initial weight of the experimental fish ranged from 4.31g to 4.73g. And the initial weight of the experimental diet ranged from 1.52g to 1.66g. T4 gave the highest mean final weight of 15.31g while the lowest final mean weight was recorded in T1 with 12.38g. The best FCR, PER and mean protein intake were recorded in T 4. The benefit cost ratio was high in T4. The temperature ranged from 24.8 to 27.80°C, the pH value ranged from 6.4 to 7.8, while the dissolve oxygen recorded ranged from 5.2 to 6.2mg/L. The total dissolve solid taken ranged from 0.023 to 0.044, and ammonia 0.082 to 0.116mg/L.

According to Allan *et al.*, (2000) chicken by product meal has high protein content which is around 60%, and as such can be used to substitute fish meal in aqua feed. Therefore, the result of this study shows that processed chicken waste (chicken intestine) is a suitable replacement of fish meal in practical formulation diets for *Clarias gariepinus* fingerlings. The growth performances (final weight gain, daily gain and specific growth rate) and nutrient utilization (feed conversion ratio, protein efficiency ratio and protein utilization) of *Clarias gariepinus* fingerlings has shown increase for dietary PBM without any significant reduction even at 100% inclusion level of processed chicken intestine meal, this is in line with the findings recorded by Omitoyin and Faturoti, (2000), which stated that fish fed parboiled chicken offal showed higher weight gain than those fed with raw offal. This finding agrees with the finding of Meeker and Hamilton (2006) who pointed out that the different processing methods, amount of temperature as well as duration can influence the quality of the chicken by product meal thereby improving the

protein content. In this study it was observed that *Clarias gariepinus* fingerlings fed 75% (T1) inclusion level of processed chicken intestine meal performed better in terms of MWG, SGR, PER and FCR compare to other treatments, while treatment 1 (0%) recorded the lowest MWG. This study contradicts the work of Yilmaz *et al.* (2003) which recorded that the diets containing PBM even at lowest level significantly limited weight gain, FCR, SGR and PER that the values worsened as PBM inclusion level increased.

Table 1: Feed Compositions of the Experimental diets on Dry Matter Basis (g/100g).

Ingredients	Experimental Diets				
	T1	T2	T3	T4	T5
Inclusion levels	0%	25%	50%	75%	100%
Fish meal	29.10	24.51	14.54	7.27	0.00
Boiled Chicken Intestine meal	0.00	7.27	14.54	24.51	29.10
Soybean meal	18.85	18.85	18.85	18.85	18.85
Groundnut cake	17.75	17.75	17.75	17.75	17.75
Maize meal	15.61	15.61	15.61	15.61	15.61
Maize bran	13.91	13.12	12.21	11.31	11.92
Starch	2.0	2.0	2.0	2.0	2.0
Calcium di phosphate	1.0	1.0	1.0	1.0	1.0
Vitamin & Mineral Premixes	0.5	0.5	0.5	0.5	0.5
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Vitamin C	0.2	0.2	0.2	0.2	0.2
Salt	0.5	0.5	0.5	0.2	0.5
Calculated Crude Protein	40.00	40.00	40.00	40.00	40.00

Table 2: Proximate Compositions and Metabolizable Energy of Experimental Diets

Experi mental diets	Crude protein%	Crude lipid%	Crude fibre%	Ash%	Dry Matter%	Nitrogen Free Extract%	Metaboliz able Energy KJ/g
T1	39.67±2.05	9.82±0.11	2.62±0.03	11.93±1.06	90.48±2.33	26.44±1.02	3170.006
T2	40.06±2.12	11.96±0.21	3.54±0.02	10.18±1.02	92.55±4.22	26.81±1.21	3378.198
T3	39.88±2.06	11.91±0.11	2.45±0.06	10.06±0.89	92.59±2.01	28.21±1.09	3416.408
T4	40.09±2.11	12.27±0.31	3.25±0.01	10.09±0.78	93.38±1.22	27.68±1.07	3434.996
T5	40.03±2.01	13.04±0.41	3.11±0.02	10.18±0.54	93.14±2.01	7.05±1.02	3476.012

Table 4: Growth, Feed Utilization and Cost Benefits of *Clarias gariepinus* Fingerlings fed Experimental Diets

Indices	T1	T2	T3	T4	T5
Mean initial weight (g/fish)	4.31 ^b	4.55 ^a	4.61 ^a	4.55 ^a	4.72 ^a
Mean final weight (g/fish)	12.41 ^b	13.61 ^b	12.85 ^c	15.36 ^a	14.74 ^a
Mean weight gain (g/fish)	8.10 ^c	9.06 ^b	8.24 ^{bc}	10.81 ^a	10.03 ^{ab}
Specific growth rate (%/day)	0.547 ^c	0.566 ^{bc}	0.530 ^c	0.629 ^a	0.587 ^b
Condition factor K2	0.40 ^a	0.41 ^a	0.42 ^a	0.42 ^a	0.39 ^a
Survival (%)	85 ^c	80 ^d	95 ^a	80 ^d	90 ^b
Feed conversion ratio	0.52 ^{ab}	0.54 ^a	0.55 ^a	0.47 ^b	0.49 ^b
Mean protein Intake	11.61 ^c	13.65 ^{ab}	12.73 ^{bc}	14.24 ^a	14.01 ^a
Protein efficiency ratio	0.69 ^b	0.66 ^b	0.65 ^b	0.76 ^a	0.72 ^a
Incidence cost (#)	21.85 ^a	19.52 ^{ab}	20.10 ^a	15.15 ^b	14.64 ^b
EICA(#)	420.17 ^a	414.77 ^a	409.33 ^{ab}	403.86 ^b	386.69 ^c
Profit index (#)	0.22 ^a	0.23 ^b	0.22 ^b	0.27 ^a	0.26 ^a
Benefit cost ratio (#)	0.20 ^b	0.21 ^b	0.20 ^b	0.26 ^a	0.24 ^a

Means of data on the same row with different superscripts are significantly different ($p \leq 0.05$)

References

- Allan, G. L., S. Parkinson, M. A. Booth, D. A. J. Stone, S.J. Rowland, J. Frances and R. Warner-Smith. (2000). Replacement of Fish Meal in Diets for Australian Silver Perch, *Bidyanus Bidyanus*: I. Digestibility of Alternative Ingredients. *Aquaculture*, 186: 293-310
- Akand, A. M., Socb, M., Hasan, M. R. And Kibria, M.G., (1991). Nutritional Requirements of Indian Major Carp *Labeo rohita* (Hamilton) -1. Effect of Dietary Protein on Growth, Feed Conversion and Body Composition. *Agric International*, 1: 35-43.
- Bolorunduro P.I (2002). Feed formulation and feeding practices in Fish Culture. Fisheries Extension Bulletin vol 152, Fisheries series No.2, pp. 28
- Faturoti, E. O. and Lawal, L. A. (1986). Growth response and nutrients utilization in *Oreochromis niloticus* fed varying levels of dietary cassava peel. *Nigerian Journal of Applied Fisheries and Hydrobiology*, 2(1):47-50.
- Meeker, D., and Hamilton, C., (2006). *An overview of the rendering industry*. Essential Rendering: All About The Animal By-Products Industry.
- Naylor, R.L., Goldburg, R.J., PrimaveraNathalie, L.F., Jobling, M., Carter, C. and Pierre, B., (2010). *Finfish aquaculture diversification*. CAB International, Wallinford, UK
- Omitoyin, B.O. and Faturoti E.O, (2000). *Utilization of Raw and Parboiled Chicken Offal in catfish Clarias gariepinus* Diet. Pp. 7-11.
- Sogbesan, O.A, (2014). *Non- conventional Animal Protein Feedstuffs for the Culture of Catfish*. Ibadan University press, publishing House University of Ibadan, Ibadan-Nigeria.
- Yılmaz E., Hüseyin S, and brahim D. (2003). Replacing Fish Meal with Poultry By-Product Meal in Practical Diets for Mirror Carp (*Cyprinus carpio*) Fingerlings. Central Fisheries Research Institute (CFRI) Trabzon, Turkey and Japan International Cooperation Agency (JICA) *Turkish Journal of Fisheries and Aquatic Sciences* 3: 81-85.

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Determination of the Effect of Different Packaging Materials and Temperatures on the Quality and Sensory Attributes Of Fish Crackers

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Abstract

Packaging is a means of ensuring the safe delivery of a product to the ultimate consumer in a sound condition of the minimum overall cost. Packaging is an essential process in food products. This is done to protect the products from germs, moisture, and other airborne microorganisms. However, this process is related to fishery products as well. The aim of this study was: (1) to assess the protection function of different locally sourced packaging films with fish crackers such as Biaxially oriented polypropylene (BOPP), Low-density polyethylene (LDPE) with a thickness of 28 and 38 microns (LDPE28, LDPE38) and Aluminium at different temperature of 30, 35 and 40 °C, respectively, (2) analyze the products for sensory attributes (appearance, aroma, taste, and texture) for 4 weeks by trained panelists. From the panelist result, the most suitable packaging material from the materials investigated for storing deep-fried fish crackers is the 38-micron low-density polyethylene (LDPE38). The quality change indicates the storage quality and shelf-life stability of the products at the storage conditions (temperature and packaging materials).

Keywords: Packaging, Fish crackers, shelf life, Temperature, sensory evaluation

Introduction

Packaging of food materials is done to suitably hold the contents and keep them safely without breakage, leakage and degradation until they are used. It also helps to extend the shelf-life of food products and the convenient handling of the food materials. Packaging helps to protect the food from a different range of hazards during storage and distribution including protection from dirt, contaminants, pests, and weather conditions (Adeyemi *et al.*, 2019). It has been demonstrated that food packaging can prevent product deterioration, retain the beneficial effects of processing, extend shelf-life and maintain or increase the quality and safety of food (Marsh and Bugusu, 2007; Singh and Gray, 2011). There is an increase in consumer awareness and demand for food products of high quality, hence, the need for adequate packaging. Packaging is critical in maintaining product quality while at the same time offering protection from microbial and chemical contaminants as well as from water vapour and light (Silver *et al.*, 2004; Rejikumaret *al.*, 2007; Bibiet *al.*, 2008; Adetunji and Chen, 2011). A very important means of assuring that a product will be safely delivered to the consumer is through adequate and high-quality packaging. Packaging ensures that the product is delivered in a sound condition at the least possible overall cost (Emblem and Emblem, 1996). The three requirements that must be met by a good packaging material include: the package must ensure the safety of the product throughout its shelf-life, it must show detailed information about the producer and the contents, and the product must be preserved and protected by the packaging material (Soroka, 2007.) Appropriate packaging materials and procedures are very important as inappropriate packaging of the products could lead to the degradation and destruction of the products thereby, resulting in economic losses and exposure of consumers to health hazards (Tweed, 2005).

Appropriate packaging is, therefore, necessary to maintain the quality of fishery products and customer satisfaction. Various types of packaging made up of different materials designs and sizes are used all over the world onboard vessels during processing, transportation, storage, retail, and display. An effective fish packaging material should be able to reduce oxidation and dehydration, prevent bacterial and chemical spoilage, prevent odor (Olayemiet *al.*, 2015).

This study aimed to assess the effect of some selected packaging materials on the quality and sensory attributes of fish crackers.

Materials and Methods

Sample collection: The fish crackers used were produced at the Department of Fish Technology and Product Development, Nigerian Institute for Oceanography and Marine Research Victoria Island Lagos. The packaging materials were obtained from Idumota market, Lagos State.

Equipment: The equipment used in this work is a vacuum sealing machine, electric oven, micrometer screw gauge, weighing balance.

Packaging materials used: Biaxially oriented polypropylene (BOPP), Low-density polyethylene (LDPE) with a thickness of 28 and 38 microns (LDPE28, LDPE38), and Aluminium.

Storage temperature: The storage temperature used was 30, 35, and 40 °C, respectively.

Analysis of the sensory attributes: The sensory attributes assessed include: appearance, aroma, taste, and texture. Storage duration: the products were stored for 4 weeks.

Preparation of sample: Deeply fried fish crackers were produced and packaged in four different packaging materials namely: BOPP, LDPE38, LDPE28, and Aluminium. They were stored at different temperature conditions of 30, 35, and 40 °C for 4 weeks. At the end of each week, packaged crackers were removed and evaluated for their sensory attributes using trained 10-man panels to check the taste, smell, colour, texture, and appearance on 9 points hedonic scale with a score of 9 meaning excellent attribute. To ensure a perfect sensory taste, water was given to the panelist to drink after each evaluation.

Result and Discussion

In this study, the sensory attributes include appearance, aroma, taste, and texture. Figure 1 shows the sensory attributes of all the plastic films considered in this study at different temperatures for 4 weeks. Freshly prepared samples had higher results for the entire sensory attribute (minimum of 8 for all measured attributes) and were significantly preferred to store packaged samples investigated under different conditions.

Figure 1a shows the appearance of the fish cracker using all the packaging materials. The appearance of the LDPE38 was at its highest at 30 °C with a performance of 9 when compared with its result at 35 and 40 °C respectively at week 2. BOPP, LDPE28, and Al had low appearance results by the panelist when compared to LDPE38 at 30 °C. At week 4, the appearance of all the fish crackers in all different packaging materials was at the lowest. Figure 1b shows the result of the aroma of the fish cracker with different packaging materials. The aroma of the fish cracker at different temperatures using the different packaging materials in week 4 was at its lowest when compared with week 1. In week 2, aluminum packaging was preferred by the panelist at a temperature of 40 °C. Figure 1c shows the result of the taste of the fish cracker with different packaging materials. The taste of the fish cracker using BOPP was condemned by the panelist at 30 °C but was appreciated at 35 and 40 °C at week 4. Week 1 gave the best result at all temperatures for the panelist. Figure 1d shows the result of the texture of the fish cracker with different packaging materials. Week 1 gave the best texture at all temperatures by the panelist but was at its least a week 4. LDPE28 gave the lowest result at all temperatures when compared to other packaging materials.

However, differences are not significant ($p > 0.05$) among the samples packaged with the packaging films. The temperature and duration of storage significantly affected the physical appearance of the sample. These sensory attributes affected the choices made by the panelists as the products were packaged and stored in BOPP, LDPE38, LDPE28, and Aluminium foil. The results obtained were contrary to the results obtained by Abonget *et al.*, 2011. They investigated the effect of packaging using aluminum foil and polyethylene bags on potato crisp and concluded that aluminum packaging was more effective than polyethylene bags. The variation in result could be a result of the rancidity of the oil used for frying the fish crackers which is a critical factor in limiting the shelf life (Asap and Austin, 1986). Figure 1 also indicates that the panelist was able to detect the changes that occurred.

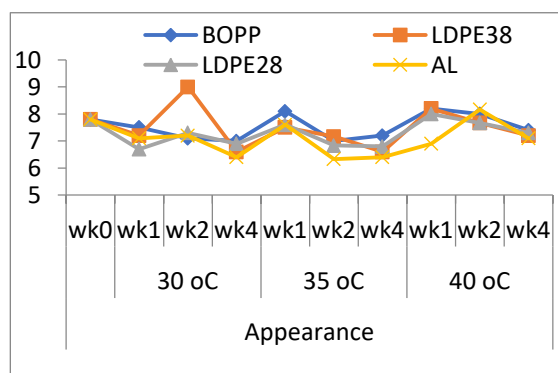
Conclusion

The quality attributes and shelf-life stability of deep-fried fish crackers were established by checking the influence of the type of packaging film, the storage temperature, and the duration of storage. The most suitable packaging

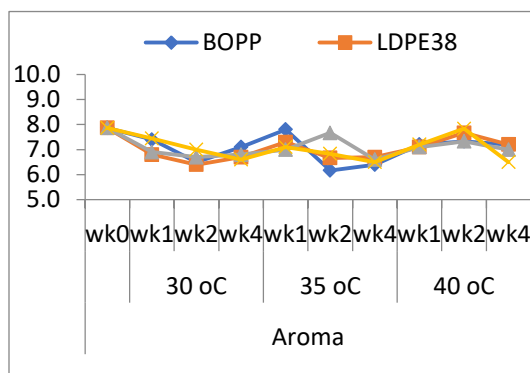
material from the materials investigated for storing deep-fried fish crackers is the 38-micron low-density polyethylene (LDPE38).

References

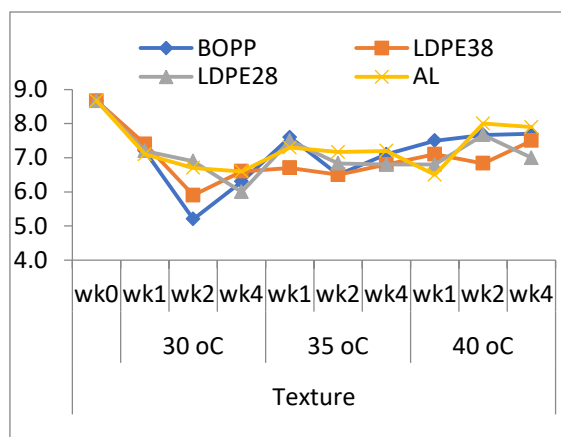
- Abong, G. O., Okoth, M. W., Imungi, J. K., and Kabira J. N. (2011). Effects of packaging and storage temperature on the shelf life of crisps from Kenyan cultivars. *American Journal of Food Technology*, 6(10): 882-892
- Adeyemi, R.S., Olajuyigbe, O.O., Shittu, A.S. Musa, M., Okeleye, A.A., Yusuf, H., Rayyanu, H. Olusola, A. O. Ezekiel, M. O. Fawale, S. O. Jackson, I. Udoezika, U. C. and Egbunonu, G. C. (2019). Determination of Water vapor transmission rate of locally-sourced packaging materials. Proceedings of the 34th Annual Conference of the Fisheries Society of Nigeria (FISON). Ebonyi 28th October -1st November. Pp 101-104.
- Asap, T. and Augustin, M. A. (1986). Effect of frying oil quality and TBHQ on the shelf life of potato crisps. *International Journal of Science and Food Technology*, 11: 177-181.
- Bibi, N.A.B., Khattak, A. and Mehmood, Z. (2018). irradiation and packaging food safety aspects and shelf life extension of solar-dried garlic (*Allium sativum*) powder. *American Journal of Food Technology*, 3: 118-126.
- Marsh, K. and Bugusu, B (2007). Food packaging- roles, material, and environmental issues. *Journal of Food Science*, 72:39-55.
- Emblem, A. and Emblem H. (1996). Fundamentals of Packaging Technology. Melton Mowbray. The Institute of Packaging, 231-234.
- Rajikumar, R., K. Dushyanthan, R., Asha, R., and Kumar, S. S. (2007). Effects of modified atmosphere packaging on microbial and physical qualities of Turkey meat. *American Journal of Food Technology*, 2: 183-189.
- Silva, A.S., Hernandez, J.L. and Losada, P.P. (2004). Modified atmosphere packaging and temperature effects on potato crisps oxidation during storage. *Anal. Chim. Acta*, 524: 185- 189.
- Singh, N and P S., Rajini (2004). Free radical scavenging activity of an aqueous extract of potato peel. *Food chem.*, 85: 611- 616.
- Singh, P. and Goyal, G.K. (2011). Combine atmosphere packaging with the shelf life of ready-to-serve pizza with Biochemical and sensory attributes. *American Journal of Food Technology*, 6: 202- 214.
- Soroka, W. (2007). Fundamentals of Packaging Technology. 3rd Edition. Institute of Packaging Professionals. UK. www.amazon.com. Accessed 24-04-2010.
- Tweed, D. (2005). The Origins of Paper-based Packaging Conference on Historical Analysis and Research in Marketing Proceeding. HTTP: Faculty Quinnipiac.edu/charm, 2005, 288-300.



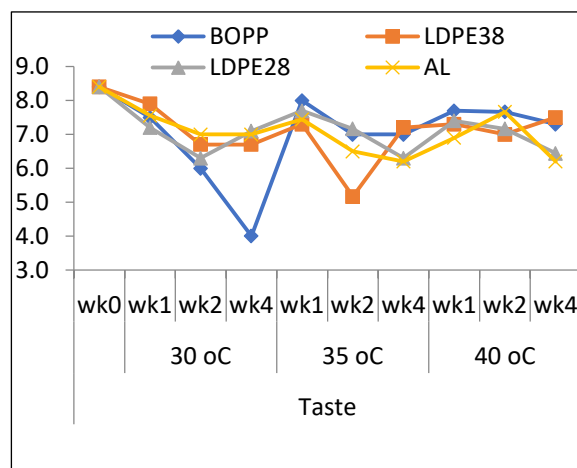
(a)



(b)



(c)



(d)

Figure 1: Sensory attributes of fried fish crackers packaged in different packaging films stored at 30, 35, and 40°C for 4 weeks (a) appearance (b) aroma (c) Taste (d) Texture

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Effects Of Ginger (*Zingiber officinale*) and Garlic (*Allium sativum*) on the Microbiological Properties Of Minced Tilapia (*Oreochromis niloticus*) and Croaker (*Pseudotolithus senegalensis*) Fishes At Ambient Temperature

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Abstract

The study evaluated the effect of ginger and garlic on the microbiological properties of minced tilapia and croaker fishes at ambient temperature. Twenty (20) live fresh tilapia (*Oreochromis niloticus*) and croaker (*Pseudotolithus senegalensis*) fishes (10 samples of each fish), fresh ginger (*Zingiber officinale*) and garlic (*Allium sativum*) were purchased from some selected markets in Yenagoa Metropolis, Yenagoa, Bayelsa State. The fishes were processed in-line with standard methods. The ginger and garlic were cleaned and ground properly into fine pastes and applied as ginger and garlic spice mixture to the 4 batches of fishes. A batch of the fish samples was also left untreated (Control), while a batch was treated with ginger and garlic mixture (Synergy). These were stored at ambient temperature of about 25-30°C for 5 days, and thereafter subjected to microbiological examinations during the storage interval. Analysis of data obtained from the colonial counts (in cfu/g) of bacterial and fungal isolates under the 5 days survey showed that there was no significant ($p > 0.05$) between days 3 and 5 in the *Staphylococcus* sp concentration of the croaker fish samples, while between days 1 and 2, there was significant difference ($p < 0.05$). *Escherichia coli* showed no significant differences ($p < 0.05$) between days 1 and 5. Similar trend was observed between days 3 and 5 for *Shigella* sp. In days 1 and 2, there were significant differences in *Shigella* spp concentration. There were significant differences in the *Salmonella* spp concentration between days 1 and 3, while in days 4 and 5, there was no significant difference ($p > 0.05$) in *Salmonella* concentration. There was no significant difference in the fungi concentration in days 1 and 2, similar trend was observed in day 3 to 5.

Keywords: Shelf life, Processing, Preservation, Microbial load, Handling

Introduction

Fishes are essential resources for mankind. They are used as food, leather material, research tools, etc (Idris *et al.*, 2010; Amuneke *et al.*, 2020). The economic importance of fishes to fish farmers, vendors and food industries cannot be overemphasized. These benefits derived from fishes may be lost if they are not preserved properly. Fish preservation is therefore an important aspect of fish farming and marketing. It helps to extend the shelf-life of the fishes. Poorly preserved fishes are greatly exposed to microbial contamination and spoilage, and in due time, the fishes may become useless (Okereke and Ezeafulukwe, 2018). Due to poor handling, processing and preservation, about 30-50% of fishes harvested in different parts of Nigeria are wasted as a result of microbial attacks. These losses could be minimized by the application of proper handling, processing and preservation techniques. Fish spoilage leads to economic loss to fish farmers and vendors. It also exposes consumers to microbial food poisoning. Spoilage of fishes proceed through series of complex enzymatic, bacterial and chemical changes which begins when the fish is harvested (Abdul *et al.*, 2008; Idris *et al.*, 2010).

However, synthetic antioxidants such as; butylated hydroxytoluene (BHT), butylated and hydroxyl anisole (BHA), had been very effective in inhibiting microbial spoilage of fishes but their carcinogenic, mutagenic and organ damage pose a serious health challenges to consumers. (Food and Agriculture Organization (FAO), 2015). Hence, these synthetic antioxidants have been withdrawn from the market, because of their undesirable effect on the enzymes of the liver and lungs of humans who consumed these treated fishes. Other synthetic preservatives may be regarded as safe, and expensive for rural subsistent fish farmers and vendors to purchase on a regular basis. There is therefore need to create awareness in these rural communities on the availability of cheaper means of preserving fishes using natural raw materials such as onion, ginger, garlic, etc, without losing their nutritional and market values (Amuneke *et al.*, 2020). It therefore becomes essential to evaluate the potency of ginger and garlic in extending the shelf-life of fishes (particularly croaker and tilapia).

Materials and Methods

Twenty (20) live fresh fish samples (10 tilapia (*Oreochromis niloticus*) and 10 croaker (*Pseudolithus senegalensis*), fresh ginger (*Zingiber officinalae*) and garlic (*Allium sativum*) were purchased from selected markets in Yenagoa Metropolis, Yenagoa, Bayelsa State, and were immediately transported to the laboratory on icepacks for fishes and sterile polythene bags for the ginger and garlic. Microbiological analysis was carried out by spread plate technique. Colonies observed were counted and recorded according to Goldman and Green (2008). The bacterial and Fungal counts (in CfU/g) of the minced tilapia and croaker fish samples during the storage intervals, was analyzed using the ANOVA (Analysis of Variance) Package. Prevalence of bacterial isolates from the two fish samples was expressed in tables.

Results and Discussion

Analysis of data obtained from the colonial counts (in cfu/g) of bacterial and fungal isolates that grew on the culture media is shown in Table 1. There was no significant ($p > 0.05$) between days 3 and 5 in the *Staphylococcus sp* concentration in the croaker fish samples, while between days 1 and 2, there was significant difference ($p < 0.05$). *Escherichia coli* showed no significant differences ($p < 0.05$) between days 1 and 5. Similar trend was observed between days 3 and 5 for *Shigella sp*. The *Staphylococcus aureus*, *Escherichia coli*, *Shigella sp*, *Salmonella sp* and Fungi were high in the Control. There was no significant difference in the fungi concentration in days 1 and 2, similar trend was observed in day 3 to 5. This was followed with the one treated with 2% ginger. The organisms were reduced further with 2% garlic, followed by 2% synergy.

Table 1: Analysis of the Prevalence of Bacterial Isolates and Fungal Colonial Counts for the Croaker and Tilapia Fish Samples

FISHES	DAYS	MICROBIAL ISOLATES				
		<i>Staphylococcus aureus</i>	<i>Escherichia coli</i>	<i>Shigella sp</i>	<i>Salmonella sp</i>	FUNGI
CROAKER	1	9.31±30.08 ^c	23±4.37 ^a	9.81±3.54 ^c	0.00±0.00 ^c	1.25±0.67 ^b
	2	36.06±10.38 ^b	48.81±12.58 ^a	25.56±7.23 ^{bc}	16.5±4.89 ^{bc}	4.81±2.36 ^b
	3	70.56±6.14 ^a	57.5±11.05 ^a	61.62±6.10 ^a	58.56±10.83 ^a	60.5±8.24 ^a
	4	70.56±6.14 ^a	57.5±11.05 ^a	61.62±6.10 ^a	58.56±10.83 ^a	60.5±8.24 ^a
	5	70.56±6.14 ^a	57.5±11.05 ^a	61.62±6.10 ^a	58.56±10.83 ^a	60.5±8.24 ^a
TILAPIA	1	13.56±4.02 ^c	19.69±3.66 ^a	12.13±3.56 ^c	0.00±0.00 ^c	0.63±0.28 ^b
	2	23.44±7.28 ^{bc}	40.69±8.54 ^a	25.94±7.90 ^{bc}	10.56±3.34 ^{bc}	3.88±1.77 ^b
	3	49.5±5.89 ^{ab}	44.25±7.61 ^a	49.38±5.87 ^{ab}	38.88±7.30 ^{ab}	43.25±6.55 ^a
	4	49.5±5.89 ^{ab}	44.25±7.61 ^a	49.38±5.87 ^{ab}	38.88±7.30 ^{ab}	43.25±6.55 ^a
	5	49.5±5.89 ^{ab}	44.25±7.61 ^a	49.38±5.87 ^{ab}	38.88±7.30 ^{ab}	43.25±6.55 ^a
OVERALL		44.26±2.61	43.74±2.93	40.64±2.39	31.94±2.88	32.18±2.67

Means within the row with different superscripts are significant at $p < 0.05$

Note: numbers 1-5 represent different days

Discussion

The obtained bacterial and fungal counts (in CfU/g) exceeded the specifications of the Microbiological Guidelines for Foods stipulated by the Centre for Food Safety (2014), which certified counts greater than 10^2 as unsatisfactory and those less than 10^2 as satisfactory. The high microbial counts obtained from the study could be attributed to the reducing keeping quality of the natural preservatives and the suitable room temperature environment, which permitted the adaptation and proliferation of the bacterial and fungal species over the study time intervals. Okereke and Ezeafulukwe (2018) highlighted the progress of contamination processes in relation to exposure in time intervals. They reported that exposure time is significant as it provides more rooms for the proliferation and the contamination activities of the infectious agent(s). The study found out that ginger and garlic were effective in extending the lifespan of the croaker and tilapia fish samples, but that this activity started diminishing with increase in the storage time interval. These findings agreed with the studies of Amuneke *et al.* (2020), who reported the effectiveness of natural spices in reducing microbial attacks.

Conclusion

The bacterial counts obtained from this study revealed the extent at which fishes could be contaminated with microorganisms, if no proper washing or treatment process is undertaken *ab ini tio* before final consumption. The study also proved the effectiveness of the natural preservatives (ginger and garlic) in extending the shelf-life of fishes, but that this tendency could be affected in relation to storage intervals

References

- Amuneke, K.E.; Oguntade, O.R., Ikeogu, F.C. and Nomehu, A. (2020). Effect of natural preservatives on the organoleptic characteristics and storage stability of smoked *Heterotis niloticus*. *Journal of Tropical Agriculture, Food, Environment and Extension*. 9(2), pp. 31-35.
- Abdul, A.B.; Abdel-Wahab, S.T.; Al-zubari, A.S.; Elhassan, M.M. and Murali, S.M (2008). Anticancer and antimicrobial activities of zerumbone from the rhizome of *zingiber zerumbul*. *International Journal of Pharmacology*, 4:301-304.
- Food and Agriculture Organization (FAO) (2015). Handling of fish and fish products, Fisheries and aquaculture department, Rome. Updated 27 May 2015.
- Goldman, E. and Green, L. (2008). *Practical Handbook of Microbiology*. Taylor and Francis Group, second edition, CRC Press, USA. P864
- Idris, G.I.; Omojowo, F.S.; Omajisola, P.F.; Adetunji, C.O. and Ngwu, E.O. (2010). The effect of different concentration of ginger on the quality of smoked dried catfish (*Clarias gariepinus*). *Nature and Science*, 8:59-63.
- Okereke, A.N. and Ezeafulukwe, C.F. (2018). Effects of soaking time intervals of heavy metals in oyster in a contaminated zone in Rivers State. *Nigerian Journal of Fisheries*, 15(1); 2-6.
- Okereke, A.N.; Ezeama, C.F.; Ojinnaka, M.C. and Ike-Obasi, J.C. (2017). Effect of depuration on microbial load of oyster harvested in a polluted creek in Rivers State. Proceedings of the 41st NIFST Conference and Annual General Meeting, 2017, 2-3.

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Sweet Potatoes Peel Meal as Alternative Carbohydrate Source in the Diet of *Clarias gariepinus* Fingerlings

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Abstract

Fingerlings of *Clarias gariepinus* were stocked randomly into eight tanks at 10 fingerlings per tank and subjected to four treatments with each treatment replicated twice. Sweet Potatoes Peel Meal (SPPM), which is the test ingredient, was included at 0%, 50%, 75%, and 100% in the four diets formulated at 40% crude protein. The experiment lasted for 56 days (8 weeks). Fish fed with diet D3 (75% inclusion level) had the best growth rate with specific growth rate of 2.03 ± 0.03 , feed conversion ratio of 1.21 ± 0.06 and protein efficiency ratio of 1.32 ± 0.22 while fish fed with diet D4 (100% inclusion level) had the least growth rate with specific growth rate of 2.04 ± 0.04 , feed conversion ratio of 1.39 ± 0.09 and protein efficiency ratio of 1.44 ± 0.33 . There was no significant difference in all the growth and nutrient utilization data for fish fed diets D2 and D4 but they differed significantly from fish fed diet D1 and D3. It can be concluded that Sweet potatoes meal can replace maize up to 75% inclusion level as an energy source in the diets of *Clarias gariepinus* fingerlings without adverse effects on nutrient utilization and growth performance. From the study, the use of Sweet potatoes peels to replace maize which is a highly competitive source of carbohydrate in fish diet had the best result in terms of nutrient utilization and growth at 75% inclusion level and was significantly different from the control (0% inclusion level).

Keywords: Sweet Potato, Byproduct, Feed Utilization, *Clarias gariepinus*

Introduction

Sweet potato is one of the most widely grown food crop in the world. It is cultivated in about 111 countries with a total of 110.75 million tonnes produced in 2013. China alone accounts for about 71% of the production. The global amount of sweet potato waste in 2011 accounted for about 7% of the entire crop (FAO, 2016). Sweet potato is a root tuber which is rich in carbohydrates and minerals and has a high moisture content. On dry basis, sweet potato contains 80-90% carbohydrate, of which 60-70% is starch. However, the ratio of starch to other carbohydrates such as sugar and the general relative composition of the root tuber vary with cultivars, maturity and storage time (Woofe, 1992). Other useful components present in sweet potatoes include proteins, vitamins, carotenoids, polyphenols, and minerals. Sweet potato high carbohydrate content has established it as an energy dense stable food in many countries (Woofe, 1992; Sun, *et al.* 2014). The processing of the root tuber into starch, alcoholic beverages, ethanol, flour, purees, and other commodities generates byproducts such as peels that currently have very little utilization and normally add to the waste going into landfill and bodies of water.

Another important byproducts of sweet potato production are vines and leaves that comes from the agricultural phase. Vines and leaves are a good source of protein, vitamins, minerals, pigments, and polyphenols. However, with exception of small scale farms that use this byproduct to feed farm animals, vines and leaves have very little application. Animal feed. Both roots and tops apart from being used fresh, could be made into a dried meal and fermented silage and fed to livestock, including pigs, cattle and poultry. This use is quite significant in China, the USA, Taiwan and India (Scott, 1992; Woolfe, 2007). The objective of this study therefore is to utilize the waste that is generated from processing to investigate the effect of replacing sweet potatoes peel meal with maize meal in diet of *Clarias gariepinus* fingerlings.

Materials and Methods

Collection and preparation of sweet potatoes peels meal (SPPM). Fresh peels of sweet potatoes (Table 1) were collected from women frying sweet potatoes for sale at Akwanga, Nasarawa State. The collected samples were washed thoroughly with clean tap water to remove dirt and debris, drained and sun dried to a constant weight. The dried peels were milled using a laboratory miller and packed in a freezer at -20°C until use.

Diets Formulation and Storage

The diets were formulated at the Fisheries Technology Laboratory Department of Fisheries Technology, College of Agriculture Lafia. The diets were prepared as isonitrogenous 40% crude protein. Four test diets formulated using plant and animal sources. The sweet potato powder meal and maize meal was incorporated at 0%, 50%, 75%, and 100% inclusions levels. All the ingredients were obtained in a dry form. During the production of the sinking diet, whole maize and sweet potatoes peel, soya bean meal were processed in order to reduce anti-nutritional factors and improve nutrient bioavailability to the fish (Sinha, *et al.* 2021). The other ingredients used in the production of the sinking diet were not subjected to any processing. Thus, whole maize, soya bean and sweet potato peel were soaked in freshwater for overnight and eight (8) hours respectively. They were then boiled for half to one hour followed by solar-drying for about a day. Solar-drying was followed by dry cooking (roasting) for maize and finally solar-dried again. Dried ingredients were milled into fine particles using a grinder machine (hammer mill) with a screen size of 0.8mm, weighed and mixed in the required proportions according to formulation. The mixture was then blended with sufficient hot water to form a dough. Pellets were produced by extruding this dough through a meat grinder/mincer with a die size of 2mm and subsequent solar-dried for several hours until dry. A dried sample of each diet was sent to the Department of Zoology laboratory, University of Jos for proximate nutrient analysis (moisture, protein, oil, fibre, ash) using standard methods (AOAC, 2006). Moisture was determined by oven drying the ingredients at 105°C for 24 hours. Crude protein (N x 6.25) was determined by Kjeldahl method after digestion with concentrated H₂SO₄. Ash content was determined by incineration in a muffle furnace at 600°C for 16 hours. Crude lipid was determined by NaOH and 1.25% H₂SO₄. Gross energy was calculated using the conversion factors for protein, lipids and carbohydrates provided (Tacon, 1990). Nitrogen Free Extract (NFE) was calculated by subtracting the sum of moisture, protein, oil, fibre and ash from 100.

Table 1: Proximate composition of sweet potato peel

Nutrient content	Composition (%DM)
moisture	8.06
Crude protein	5.01
Ash	4.55
Crude lipids	3.97
Crude fibre	3.82
NFE*	74.59

*Hydrolysable carbohydrate content computed as Nitrogen Free Extract (NFE)

Table 2: Composition of the Diets Fed To *Clarias gariepinus* Fingerlings For Eight (8) Weeks

Ingredients	DIETS DESIGNATION IN GRAMS.			
	TD1 0% SPPM	TD2 50% SPPM	TD3 75% SPPM	TD4 100% SPPM
Maize meal	12.72	6.36	3.18	-
Sweet potato peel meal	-	6.36	9.54	12.72
Fish meal	13.21	13.21	13.21	13.21
Groundnut Cake	26.43	26.43	26.43	26.43
Soya Bean Meal	39.64	39.64	39.64	39.64
Salt	0.5	0.5	0.5	0.5
Vitamin C	0.5	0.5	0.5	0.5
Bone Meal	1.5	1.5	1.5	1.5
*Fish Premix	0.5	0.5	0.5	0.5
Fish oil	4.00	4.00	4.00	4.00
Lysine	0.5	0.5	0.5	0.5
Methionine	0.5	0.5	0.5	0.5
Total	100.00	100.00	100.00	100.00

Experimental Design

The experimental fish were acclimatized in eight (8) circular plastic tanks each measuring 30 cm diameters, 28cm depth and 40 litres capacity were used for the experiment. The 8 plastic tanks were filled with water. The tanks were each stocked with 10 fingerlings of *Clarias gariepinus*. The tanks were randomly arranged into four (4) treatments

with two (2) replicates each. Replicates were designed 1A, 1B, 2A,2B, 3A, 3B, 4A, 4B for each treatment diet and tank.

The fish were acclimatized for 14 days at a mean temperature of 27°C±0.07. During the period; fish were fed 5% of the body weight daily with prepared diets. Fish were then starved for 24 hours before the commencement of the feeding experience. The fish weighed at the onset of the experiment and fed to satisfaction thrice (3x) daily for seven days a week throughout the experimental period. The experiment lasted for eight (8) weeks, during this period, three quarters of the water and uneaten foods in the circular tanks was siphoned out and refilled with the same quantity of water once and weekly and fish were fed thrice and remained undisturbed until the next day.

2.3 Data collection. The weight and length of each fingerling in each tank was measured at the commencement of the experiment. Subsequently, 5 fingerlings were taken randomly from each tank once a week and weighed with beam balance to access the growth rate. Total length (cm) of individual fingerling was measured from the tip of the snout (mouth closed) to the extended tip of the caudal fin using a measuring board (±0.1cm). The sampling exercises were carried out in the morning before feeding the fish. Any dead fish is quickly removed and recorded to mortality rate. The experiment lasted for 8 weeks. Water temperature record was taken daily before feeding (7.00-8.00) with graduated mercury-in-glass thermometer. Dissolved oxygen and pH were also determined using pH meter (pen type model pH-009-111). Data collected were calculated using the following formulae:

Daily Growth Rate. $DGR = \frac{wf - wi}{t}$

Where wf = final average weight at the end of the experiment

Wi = initial average weight at the beginning of the experiment

t = culture period in days

Specific Growth Rate % per day. $SGR = 100 \times \frac{\ln(\text{mean final weight}) - \ln(\text{mean initial weight})}{\text{Time(days)}}$

Food Conversion Ratio (FCR). $FCR = \frac{\text{Dry weight of diet (g)}}{\text{Total wet weight gain by fish (g)}}$

Protein Efficiency Ratio (PER). $PER = \frac{\text{Total wet weight gain by fish (g)}}{\text{Protein intake}}$

Survival Rate (SR)% = $SR = \frac{Ni}{No} \times 100$

Where Ni = Total number of fingerlings at the end of the experiment.

No = Total number of fingerlings stocked at the beginning of the experiment.

Statistical analysis.

One way analysis of variance (ANOVA) was used at 5% level of significance to determine significant difference between and within treatments. Least significant difference (LSD) was used to test which pair of the treatment means differed significantly from each other. Results with p<0.05 were considered statistically significant. All statistical analysis were performed using SPSS for window version 20 (SPSS, Inc).

Results

Nutrient Utilization and Growth of Experimental Fish

Table 3 shows the mean weight gain, the average daily weight gain (ADWG), the specific growth rate (SGR), protein efficiency ratio (PER) and feed conversion ratio (FCR) of the experimental fish. The highest weight gain (68.89±1.07) was achieved with the fish fed diet D3 containing 75% inclusion level of Sweet Potato Peel Meal (SPPM) followed by the fish fed diet D1 (61.60±1.28) with 0% inclusion level and the least weight gain (69.97±1.12) was recorded with the fish fed diet D4 containing 100% inclusion level of SPPM. All other parameters recorded followed the same trend with best values recorded for fish fed D3, followed by that fed D1, while the least was recorded in fish fed D4. However, there were no significant differences (p>0.05) between the weight gain, ADWG and PER for diets D2 (50% inclusion level) and D4 (100% inclusion level) but there was significant difference (p<0.05) between diet D3 and the other diets. For SGR, there were no significant differences (p>0.05) between any of the four diets while for FCR, there were no significant differences (p>0.05) between the values for diets D1, D2 and D4 but they differed significantly from the values for other diets, there was significant difference

($p < 0.05$) between the value for diet D3 and all other diets, and between diet D3 and all other diets with D4 having the poorest FCR value.

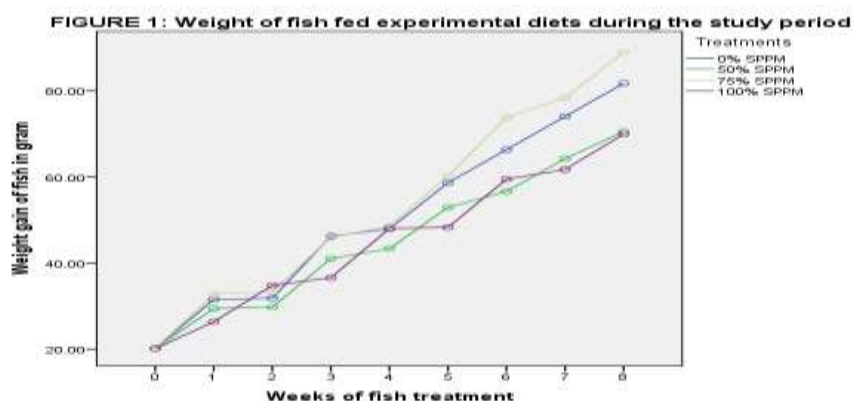
TABLE 3: Performance Evaluation of *Clarias gariepinus* fingerlings fed Sweet Potatoes Peel meal.

Parameters	Diet D1 0% SPPM	Diet D2 50% SPPM	Diet D3 75% SPPM	Diet D4 100% SPPM
Initial weight (g)	20.16±1.01 ^a	20.15±0.69 ^a	20.14±0.22 ^a	20.13±0.55 ^a
Final weight (g)	81.76±2.11 ^b	70.55±2.44 ^c	89.03±1.52 ^a	69.97±1.12 ^c
Weight gain (g)	61.60±1.28 ^b	50.40±2.23 ^c	68.89±1.07 ^a	49.84±1.66 ^c
Survival %	98±2.10 ^b	100±0.00 ^a	100±0.00 ^a	95±5.37 ^c
Average Daily Weight Gain	1.1±0.07 ^b	0.90±0.06 ^a	1.23±0.05 ^c	0.89±0.11 ^a
Specific Growth Rate	2.05±0.07 ^a	2.07±0.05 ^a	2.03±0.03 ^a	2.04±0.04 ^a
Protein Efficiency Ratio	1.13±0.06 ^a	1.47±0.09 ^c	1.32±0.22 ^b	1.44±0.33 ^c
Feed Conversion ratio	1.35±0.24 ^a	1.36±0.08 ^a	1.21±0.06 ^b	1.39±0.09 ^a

Means ($\pm$ SE) with the same superscripts along the same row are not significantly different by Duncan's Multiple Range Test (DMRT) at 5% ($p < 0.05$) level of probability.

Table 4: Mean water quality parameters recorded during the experimental period

Tank	Temperature ($^{\circ}$ C)	DO (mg/litre)	pH
D1	26.90±0.10	6.10±0.00	6.90±0.00
D2	26.75±0.05	5.10±0.00	7.75±0.05
D3	26.75±0.05	5.10±0.00	7.10±0.00
D4	26.80±0.10	6.05±0.05	6.75±0.05



Discussion

At the end of the study, the result shows that sweet potatoes peel meal can serve as a replacement for maize in enhancing productivity in the diet of the African catfish *Clarias gariepinus* fingerlings. All the experimental diets were accepted by the experimental fish indicating that the incorporation of sweet potatoes peel meal in fish diets did not have adverse effect on the palatability of the experimental diets. This might be attributed to the processing technique which the sweet potatoes peel meal was subjected to prior to formulation. This findings agrees with Fangbero (1999) and Becker (2003) who reported that reduction in anti-nutrient by different processing techniques resulted in better palatability and growth in fish. Weight gain decreased as sweet potatoes peel meal was included in up to 100%, an indication that at higher level of inclusion, above 75%, it may have a deleterious effect on growth. The result obtained in this study is in agreement with the result obtained by Omoregie *et al.* 1991 when they included cassava peelings and mango seeds in the diets of *Oreochromis niloticus*. Also, Ofojekwu *et al.* 2003 reported a decrease in weight gain of *Oreochromis niloticus* with an increase in levels of palm kernel meal.

Conclusion

The high cost of maize which is the major carbohydrate source in fish diet has been a problem in fish culture; this is addressed in the present study in the use of sweet potatoes Meal as a replacement for maize in fish feed. Sweet potatoes peels which are usually discarded after the processing of sweet potatoes has proved to be efficacious in animal feed preparation. It was also observed that when considering the cost, all the feeds from 50 – 75% inclusion of Sweet potato peels were less costly than the maize – based diet, which means they would be more economical than the maize based diet. Potato peels as a by-product from potato processing are available in large amount and their utilization may eliminate a substantial pollution problem. Thus, several tons of sweet potato peels if processed and incorporated into fish feed can reduce the cost of fish feed thereby alleviating financial problem faced by many farmers in developing countries in feeding fish.

References

- A.O.A.C., (2006). Official methods of Food Analysis of the Association of Official Analytical Chemists 18th edition. Washington D.C.
- Camire, M.E., Kubow, S. and Donnelly, D.J. (2009). Potatoes and Human Health. *Critical Reviews in Food Science and Nutrition*, 48, 823-840. <https://doi.org/10.1080/10408390903041996>.
- Fangbenro, O.A. (1999). Comparative evaluation of heat-processed winged bean (*Psophocarpus tetragonolobus*) meals as partial replacement for fish in diets for African catfish (*Clarias gariepinus*). *Aquaculture Res.* 35:1261 -1269
- FAO, (2016). Statistical website online Available from <<http://faostat3.fao.org/home>>. Accepted April 18, 2016.
- Kure, O.A; Nwankwo, L., and Wyasu, G. (2012). Production and quality evaluation of garri- like product from sweet potatoes. *Journal Natural Production and Plant Resources*, 2012, 2 (2):318-321.
- Ofojekwu, P.C., Onuoha, P.C., and Ayuba, V.O. (2003). Substitution of cotton seed cake with palm kernel meal in the diets for *Oreochromis niloticus* (L). *J.Aquat.Sc.* 18:59-63.
- Scott, G. J. and Ewell, P. (1992). Sweet potato in African Food Systems. In: *Product Development for Root and Tuber crops*. Vol. III.
- Tacon, A.G.J. (1993). Feed ingredients for warmwater fish and other processed feedstuffs FAO Fisheries Circular No. 856, FAO. Rome.pp:64
- Woolfe, J. A. (1992). Sweet Potato: An untapped Food Resource. Cambridge University Press, Cambridge, U.K.
- Woolfe, J. (2007). Sweet potato: An untapped food resource. *Cambridge University Press*, Cambridge, UK.

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Proximate and Mineral Composition of Commercial Fish Species from Owan River and their Potential Contribution to Nutrient Intake

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Abstract

Over the years, fish have become an irreplaceable food source for animal protein particularly among the socio-economic disadvantaged and rural households in Nigeria. The aim of this study is to provide data on the nutrient profiles of commercial freshwater fish species from Owan River, Nigeria and estimate their nutrients' potential contribution to the recommended nutrient intakes (RNIs) for pregnant and lactating women (PLW), adults and children in rural communities situated along the watercourse. The fishes were captured over a period of twelve months (February 2018 to January 2019) and three composite samples from each species were analyzed using accredited methods. Result of the nutrient composition of *Clarias gariepinus* and *Tilapia zilli* revealed moisture content of 68.00% and 68.75 %; protein value of 16.52 % and 17.62%; lipid value of 7.18% and 1.75 %; and ash content of 3.56 % and 4.34 % respectively. Sodium ranged from 3.92 to 5.26 mg/100g, potassium from 6.84 to 10.62 mg/100g, magnesium from 1.82 to 3.16 mg/100g, calcium from 2.25 to 4.67 mg/100g, iron from 4.01 to 8.33 mg/100g and zinc from 0.87 to 2.52 mg/100g. The potential contribution of each species to RNIs indicated that *C. gariepinus* contributed $\geq 25\%$ of RNIs for iron and zinc in children from a standard portion; while *T. zilli* contributed $\geq 25\%$ of RNIs for iron in PLW and children. This work has provided vital information which should guide in diet formulation, thereby curtailing the prevalence of nutritional deficiencies among rural households in Nigeria.

Keywords: Nutrient composition, *Clarias gariepinus*, *Tilapia zilli*, Owan River, Recommended nutrient intakes.

Introduction

Fish is one of the healthiest, relatively cheap and available sources of animal protein and other important nutrients required in human diets. It contributes significantly to food security and provides relief from malnutrition especially in many developing countries (Oboh *et al.*, 2019). In Nigeria, fish is an irreplaceable animal-source food which accounts for about 40% of the total animal protein consumed by its citizens (Kabaherda *et al.*, 2009), and more than 60% of the total protein intake in adults especially in rural areas. The proximate body composition of fish is the relative amounts of moisture, fat, protein, ash and carbohydrate contents. It also includes the mineral elements - potassium, calcium, sodium, iron, phosphorous, chlorine, and other mineral elements which occur in trace amounts (Adewumi *et al.*, 2014). The divergence in the nutrient profile among fishes has been attributed to several factors such as age, gender and diet (Moss *et al.*, 2009). Even with the abundance of freshwater bodies containing assortment of fishes in Nigeria; there still exist the prevalence of micronutrients deficiencies with its attendant human development implications among pregnant and lactating women (Ejezie and Nwagha, 2011; Ajong *et al.*, 2019; Ugwu and Uneke, 2020); adults and children (Olowole and Agboola, 2018; Amadi and Aleme, 2019) in various parts of the country.

The global sustainable development goals of zero hunger, good health and wellbeing of socio-economically disadvantaged groups specifically; has compelled need for reliable and updated scientific data on food composition to ascertain their suitability in meeting human nutritional requirements, epidemiological research, clinical practice, government policy development and implementation, and for educational purposes (Oboh *et al.*, 2019). The Owan River which transverses several communities serves as a source of commercially important fish species to the artisanal fishing households. The absence of existing data on nutrient composition of fish species in Owan River has necessitated the need for this study. Therefore, the aim of this study is to determine the proximate and mineral composition of *Clarias gariepinus* and *Tilapia zilli* from Owan River and estimate the potential contribution of selected key nutrients – calcium, iron and zinc to meeting the recommended nutrient intakes (RNI) for pregnant and lactating women (PLW), adults and children in Owan community, Edo State Nigeria.

Materials and Methods

This study was carried out at Owan River (Latitudes 006° 45' 36.5" N to 006° 45' 52.8" N and Longitudes 05° 45' 40.6" E to 05° 46' 21.8" E) in Owan community, Edo State Nigeria. The fish samples were harvested from the river with the assistance of artisanal fishermen and properly identified using taxonomic guides. Selected fish species for the study - *Clarias gariepinus* and *Tilapia zilli* were based on the species' local diet content and commercial importance. The fish samples were collected monthly from February 2018 to January 2019.

Analytical Methods: Analyses of proximate and mineral components of fish species were done in triplicate samples. The analytical methods used for the determination of moisture content, crude protein, crude fat, and minerals are described in detail by AOAC (2010).

Calculation of potential contribution to Recommended Nutrient Intakes (RNI): The potential contribution of each fish species to daily RNI was calculated in reference to the average RNI values for each nutrient as recommended for pregnant and lactating women (PLW), adults/ adolescents (8 years and above) and children (1 – 3 years). Percentage contribution to daily RNI was calculated from an assumed standard portion (36.4g/ day) of each fish species as a percentage of the average RNI. The micronutrients of interest were calcium, iron and zinc. The per capital consumption of fish as food in Nigeria is 13.3 kg (World Fish Centre, 2015), which is equivalent to 36.4g portion per day.

Results and Discussion

Proximate composition: The moisture, protein, fat and ash composition of *Clarias gariepinus* and *Tilapia zilli* are shown in Table 1. In fish tissues, water is available as bound to proteins and in the free form. The mean moisture content of the fillets of *C. gariepinus* (68.00%) and *T. zilli* (68.75%) were within acceptable levels of 60 - 80% (Gallagher *et al.*, 1991). Also, moisture content influences the texture, weight and appearance of fish. Quantitatively, protein is the second major component in fish fillets after moisture. From the nutritional perspective, protein is the most important constituent of fish which determines its wholesomeness and quality. It generally present in the range of 16 – 18% (Ninan, 2003). The mean protein content in *C. gariepinus* (16.52 g/100g) and *T. zilli* (17.62 g/100g) indicate that the fishes are good source of dietary protein for human consumption (WHO, 2007). Fish lipids are rich in polyunsaturated fatty acids particularly Omega – 3- fatty acids which are essential in human health (Obboh *et al.*, 2019). According to total fat content, *C. gariepinus* (7.18%) is categorized as intermediate (2 – 8 % total fat), which implies that they are good sources of fish oils. While *T. zilli* (1.75 %) belong to the lean fish category (< 2% total fat) an indication of poor fish oil source (EFSA, 2005). Variation in total fat content in fishes have been attributed to several factors such as species variation, age, lifecycle and size (Ninan, 2003). According to Adewumi *et al.* (2014), the ash content gives a measure of the total mineral content present in a foodstuff. The ash content in the fillets of *C. gariepinus* and *T. zilli* which ranged from 2.61 to 6.30 g/100g, indicate that the fishes are good sources of minerals such as sodium, potassium, magnesium, calcium and iron.

Mineral composition: Fish provide a well-balanced supply of mineral elements in a readily usable form, with mineral concentrations dependent on species variation (Ninan, 2003). The sodium, potassium, magnesium, calcium, iron and zinc composition of *C. gariepinus* and *T. zilli* are shown in Table 2. The ranges of sodium (3.92 – 5.26 mg/100 g), potassium (6.84 – 10.62 mg/100g) and magnesium (1.82 – 3.16 mg/100 g) content in fishes were generally consistent with ranges reported for other fish species and seafood (FAO/INFOODS, 2013; Obboh *et al.*, 2019). The analyzed mineral elements (calcium, iron and zinc) and its implication on the nutritional status of pregnant and lactating women (PLW), adults and preschool children in Owan community are discussed.

The calcium content which varied from 2.25 mg/100 g in *T. zilli* to 4.67 mg/100 g in *C. gariepinus* are within the reported range of calcium in fish and seafood (FAO/ INFOODS, 2013). None of the fish species were identified to meet $\geq 25\%$ of the RNI for PLW, adults and children (Table 3). The aim of maternal calcium homeostasis is to provide adequate calcium for fetal skeletal mineralization during pregnancy and through breast milk during infancy (Bukar and Idrisa, 2010). Reported higher systolic blood pressure in pregnant women has been significantly associated with the prevalence of hypocalcaemia among pregnant women in sub-Sahara Africa (Ajong *et al.*, 2019). Also, low dietary calcium intake among children especially from poor households has been linked to reported incidences of rickets in Nigeria (Oginni *et al.*, 2004). Poor dietary diversity in rural communities implies that the reliance of these fish species as sources of dietary calcium by PLW, adults and children in Owan community predisposes them to calcium deficiency and its attendant negative effects.

Iron content ranged from 4.01 to 8.33 mg/100 g, with mean values of 4.84 mg/100g and 7.77 mg/100g in *C. gariepinus* and *T. zilli* respectively. These values were higher than iron content reported for fish and shellfish in the global FAO/INFOODS database. *Clarias gariepinus* was identified to meet $\geq 25\%$ of the RNI of iron for children; *T. zilli* meet $\geq 25\%$ of the RNI for PLW and children, while none of the fish species provided $\geq 25\%$ of the RNI for adults (Table 3). Iron deficiency is one of the major causes of anaemia in pregnant and lactating women in Nigeria. Reported high prevalence of iron deficiency anemia (IDA) in pregnant and lactating women especially in rural communities, has been linked with adverse foetal and maternal outcomes (Ugwu and Uneke, 2020). Also, the high prevalence of IDA among preschool children (< 5 years) in various parts of the country have been reported (Olowole and Agboola, 2018). Overall, the iron content values of *C. gariepinus* and *T. zilli* observed in this study will contribute significantly to ameliorating IDA in PLW and children in Owan community in Edo State. The inadequacy of the iron content in the fish species to meet $\geq 25\%$ of the RNI for adults, implies that the adults need to consume about twice the standard portion of fish to achieve its required nutrient intake for iron, if the fishes are solely relied upon to meet dietary needs.

Zinc concentration varied from 0.87 to 2.52 mg/100g with mean values of 2.05 mg/100g and 1.43 mg/100g in *C. gariepinus* and *T. zilli*. These values were within the range of reported zinc content in fish and seafood (FAO/INFOODS, 2013). *Clarias gariepinus* was identified to only meet $\geq 25\%$ of the RNI for children; while *T. zilli* was unable to provide $\geq 25\%$ of the RNI for PLW, adults and children from a standard portion (Table 3). It is estimated that over 80% of pregnant women worldwide have inadequate zinc intake. Maternal zinc deficiency has been associated with fetal growth retardation and fetal malnutrition, which is common in developing countries (Darnton-Hill, 2013; Bolajiet *al.*, 2016). Reported clinical studies on the prevalence of maternal hypozincemia especially among the socio-economically disadvantaged PLW (Ejezie and Nwagha, 2011); adults (Amadi and Aleme, 2019) and rural preschool children (Ibeawuchi *et al.*, 2017) in Nigeria, implies that the studied fish species cannot be relied upon to meet dietary zinc requirements.

Table 1: Analytical values of the proximate composition of the fish species.

	Moisture (%)	Protein (g/100g)	Fat (g/100g)	Ash (g/100g)
<i>Clarias gariepinus</i>	68.00 $\pm$ 1.38	16.52 $\pm$ 0.69	7.18 $\pm$ 0.46	3.56 $\pm$ 0.39
<i>Tilapia zilli</i>	68.75 $\pm$ 3.11	17.62 $\pm$ 0.85	1.75 $\pm$ 0.34	4.34 $\pm$ 0.93

Values are presented as means $\pm$ standard deviations (SD) of the fish species analysed in triplicates, expressed as the nutrient content per 100 g raw edible sample.

Table 3: Analytical values of mineral composition of the fish species.

	Sodium mg/100g	Potassium mg/100g	Magnesium mg/100g	Calcium mg/100g	Iron mg/100g	Zinc mg/100g
<i>C.gariepinus</i>	4.36 $\pm$ 2.45	7.35 $\pm$ 3.10	2.61 $\pm$ 2.82	3.43 $\pm$ 5.83	4.84 $\pm$ 3.10	2.05 $\pm$ 2.01
<i>Tilapia zilli</i>	4.82 $\pm$ 3.37	9.35 $\pm$ 5.89	2.19 $\pm$ 2.01	2.83 $\pm$ 3.43	7.77 $\pm$ 3.99	1.43 $\pm$ 4.63

Values are presented as means $\pm$ standard deviations (SD) of the fish species analysed in triplicates, expressed as the nutrient content per 100 g raw edible sample.

Table 4: Potential contribution of fish in a Standard Portion, and to average daily RNI (%). Recommended Nutritional Intake (RNI)

	Calcium (mg)			Iron (mg)			Zinc (mg)		
	Adults	PLW	Children	Adults	PLW	Children	Adults	PLW	Children
Average daily RNI	1000	1040	700	16	15	7	10	7.9	3
<i>C. gariepinus</i>	1.25 (0.13%)	1.72 (0.17%)	1.25 (0.19%)	1.76 (11.00%)	2.42 (16.13%)	1.76 (25.14%)	0.75 (7.50%)	1.03 (13.04%)	0.75 (25.00%)
<i>Tilapia zilli</i>	1.03 (0.10%)	1.42 (0.14%)	1.03 (0.15%)	2.83 (17.69%)	3.89 (25.93%)	2.83 (40.43%)	0.52 (5.20%)	0.72 (9.11%)	0.52 (17.33%)

*Assumed standard portion is equivalent to 36.4g/ day for Nigerians

*Children here refers to ages 1 – 7 years.

*PLW – Pregnant and lactating women from a standard portion of 50g/day (HHS and USDA, 2015)

*RNI – Recommended Nutritional Intake.

Conclusion

Considering the role of fish in food and nutrition security especially among rural communities has necessitated their nutritional quality evaluation. This study examined the proximate and mineral composition of commercial fish species from Owan River and their potential to contribute to required nutritional intake (RNI) for a variety of nutrients in pregnant and lactating women (PLW), adults and children. The data presented here indicate that *C. gariepinus* and *T. zilliare* good sources of animal protein, while *C. gariepinus* was a good source of fish oil. The fish species were found to be good sources of mineral elements - sodium, potassium, magnesium, calcium, iron and zinc. The mineral percentage contribution to required nutritional intake (RNI) indicate that *C. gariepinus* meet $\geq 25\%$ of the RNI for iron and zinc in children; while *T. zilli* meet $\geq 25\%$ of the RNI for iron in PLW and children from a standard portion. The inability of the fish species to holistically address reported mineral deficiencies of iron, calcium and zinc in PLW, adults and children from a standard portion implies that the fishes should not be solely relied upon to meet their dietary needs. This work has provided time and location specific data for comparison with future Studies

References

- Adewumi, A.A., Adewole, H.A., Olaleye, V.F., (2014). Proximate and elemental composition of the fillets of some fish species in Osinmo Reservoir, Nigeria. *ABJNA*. 5(3): 109 – 17.
- Ajong, A.B., Kenfack, B., Ali, I.M., Yakum, M.N., Telefo, P.B., (2019). Prevalence and correlates of low serum calcium in late pregnancy: A cross sectional study in the Nkongsamba Regional Hospital; Littoral Region of Cameroon. *PLoS ONE* 14(11): e0224855. <https://doi.org/10.1371/journal.pone.0224855>
- Amadi, C., and Aleme, B. M., (2020). The prevalence of zinc deficiency among men with and without prostate cancer in Port Harcourt, Nigeria. *Nutrition and Cancer*, 72 (6): 1018 – 1025.
- Association of Official Analytical Chemists (A.O.A.C.)(2010). *Official Methods of Analysis* of the Association of Official Analytical Chemists. 18th edition, Washington D.C. USA.
- Bolaji, O.B., Adebara, V.O., Adebami, O.J., and Owa, J.A., (2016). Maternal Serum Zinc Levels and Fetal Malnutrition of Term Babies in Nigeria. *Pakistan Journal of Nutrition*, 15: 673 - 679. Doi: [10.3923/pjn.2016.673.679](https://doi.org/10.3923/pjn.2016.673.679)
- Bukar, M., and Idrisa, A., (2010). Postpartum hypocalcaemia in Maiduguri, North-eastern Nigeria: A 10-year review, *Journal of Obstetrics and Gynaecology*, 30 (7): 690 -693, DOI: [10.3109/01443615.2010.481732](https://doi.org/10.3109/01443615.2010.481732)
- Darnton-Hill, I., (2013). Zinc supplementation during pregnancy: Biological, behavioural and contextual rationale. July 2013. e-Library of Evidence for Nutrition Actions (eLENA). https://www.who.int/elena/bbc/zinc_pregnancy/en/ Assessed 10 th October, 2020.
- Ejezie, F.E and Nwagha U.I (2011). Zinc Concentration during Pregnancy and Lactation in Enugu, South-East Nigeria. *Annals of Medical and Health Sciences Research* 1(1):69-76.
- European Food and Safety Authority (EFSA) Panel on Contaminants in the Food Chain, (2005). Opinion of the Scientific Panel on contaminants in the food chain [CONTAM] related to the safety assessment of wild and farmed fish. *EFSA Journal*, 3(7):236, 118 pp. doi:[10.2903/j.efsa.2005.236](https://doi.org/10.2903/j.efsa.2005.236)
- FAO/INFOODS, (2013). FAO/INFOODS Food Composition Database for Biodiversity Version 2.1 – BioFoodComp2.1 Food and Agriculture Organization of the United Nations, Rome, Italy.
- Gallagher, M.L., Harrell, M.L., Rulifson, R.A., (1991). Variation in lipid and fatty acid contents of Atlantic croakers, striped mullet and summer flounder. *T. Am. Fish Soc.*, 120(5): 614 – 9.
- Ibeawuchi, A.N.E., Onyiriuka, A.N., Abiodun, P.O., (2017). High Prevalence of zinc deficiency in rural Nigerian Preschool children: A community based cross-sectional study. *Rom. J. Diabetes NutrMetab Dis.*, 24 (1): 031 – 039.
- Idodo-Umeh, G., (2003). *Freshwater fisheries of Northern Nigeria – taxonomy, ecological notes, diet and utilization*. ISBN 978-8052-01-0.
- Kabaherda, M.K., Omony, P., Hiisken, S.M., (2009). Post-harvest handling of low value fish products and threats to nutritional quality and life: A review of practices in the Lake Victoria region Fisheries and HIV/AIDS in Africa: Investing in Sustainable Solutions. World Fish Center Project Report 1975, 2009, 15.
- Moss, J.H., Farley, E.V., Feldman, A.M. and Ianelli, J.N., 2009. Spatial distribution, energetic status, and food habits of eastern Bering Sea age-0 walleye pollock. *Trans. Am. Fish. Soc.*, 138: 497 - 505.
- Ninan, G., 2003. Chemical composition of fish and shell fish. In Joseph, J., Mathew, P.T., Joseph, A. C. and Muraleedharan, V. (Eds). *Product Development and Seafood Safety*, p. 15-32. Cochin, India: Central Institute of Fisheries Technology.
- Oboh, I.P., Sanni, O.A., Egun, N.K., (2019). Nutritional composition of *Synodontis nigrita* and *Tilapia mariae* from the Jamieson River, Sapele, Delta State, Nigeria. *Biologija*, 65 (2): 116 – 121.

- Oginni, L.M., Badru, O.S., Sharp, C.A., Davie, M.W.J., Worsfold, M., (2004). Knee angles and rickets in Nigerian children. *Journal of Pediatric Orthopedics* 24, 403 – 407.
- Olowole, O.B., and Agboola, A.A., (2018). Dietary Iron Intake in Nigeria. *Novel Techniques in Nutrition and Food Science*, doi: 10.31031/NTNF.2018.01.000519.
- U.S. Department of Health and Human Services (HHS) and U.S. Department of Agriculture (USDA). 2015–2020 Dietary Guidelines for Americans. 8th Edition. December 2015. Available at <http://health.gov/dietaryguidelines/2015/guidelines/>.
- Ugwu, N.I., and Uneke, C.J., (2020). Iron deficiency anemia in pregnancy in Nigeria—A systematic review. *Niger J ClinPract* [serial online] 2020 [cited 2020 Oct 5]; 23:889 - 896. Available from: <http://www.njcponline.com/text.asp?2020/23/7/889/288872>
- WHO, (2007). Protein and Amino Acid Requirements in Human Nutrition: Report of a Joint WHO/FAO/UNU Expert Consultation. WHO Technical Report Series World Health Organization, Geneva, Switzerland.
- World Fish Center, (2015). Nigeria, <https://www.worldfishcenter.org/country-pages/nigeria>. Accessed 14 July 2019.

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Fillet Yield, Proximate Analysis, Mineral and Vitamin Composition of *Elops lacerta* in Epe Lagoon**Kareem, O. K¹, Adedokun M. A² and Orisasona O³**¹Department of Aquaculture and Fisheries Management, University of Ibadan, Nigeria²The Oke-Ogun Polytechnic, Saki, Oyo State, Nigeria³Department of Animal Science, Obafemi Awolowo University, Ife, NigeriaEmail: kaykaz2007@yahoo.co.uk, Corresponding author: matdokun@gmail.com**Abstract**

Fish and fish products are important to human diet because of its nutritive value, which is based on species, age and size of fish. The study aimed to document the fillet yield, proximate composition, mineral and vitamin profile of *Elops lacerta* in Epe lagoon. Samples were collected from wet and dry season, 50 samples were filleted. Proximate analysis were carried out using AOAC standards, Minerals were determined using Atomic Absorption Spectrometry, UV-VIS Spectrometry and flame spectrometry, Vitamins were determined using spectrophotometric method. Data were analyzed using Analysis of Variance. Percentage fillet yield for dry and wet season are 61.45% and 61.67% respectively, protein and fat content shows no significant difference in both seasons, the season has effect on mineral composition but not on vitamin content. It is therefore recommended that seasonal variation of nutrients should be done on other species of fish.

Key words: Vitamin, fish, proximate analysis.

Introduction

Fish plays an important role in contribution of food nutrient to the world's population (FAO, 2013). It is a source of essential nutrients which are required for supplementing both infant and adult diets across the globe (Abdullahi *et al.*, 2010). The proximate composition of fish species is paramount in estimating the quality of the fish and its utilization. The flesh of fish contains most of the minerals necessary for balanced diet. The most important mineral elements are Calcium, Magnesium, Potassium, Phosphorus, Iron and Chlorine. Calcium, magnesium, phosphorus are crucial for teeth and bone formation in the body (Kopp *et al.*, 2013). The West African ladyfish (*Elops lacerta*) is a species of fish in the Elopidae family, the body is fusiform (tapering spindle shape) and oval in cross-section; being slightly laterally compressed, and the eyes are large and partially covered with adipose eyelids.

Over the years the consumption of processed and frozen food has increased because consumers prefer convenience foods requiring less preparation time, thereby making marketing of packaged fillet products to be highly acceptable. Fillet yield has been regarded as an important trait for the improvement of fish production efficiency, it is the edible portion of the fish body and therefore excludes the frame, fins, viscera organs and scales (Flick *et al.*, 2014). Yet there is still limited information on the fillets yield of *Elops lacerta*. The aim of this study is to compare the fillet quality and composition of *Elops lacerta* during rainy and dry seasons, to assess the mineral composition of this specie in Epe lagoon during rainy and dry seasons and to evaluate its vitamin composition.

Materials and Method**Study location**

Epe lagoon lies between latitude 03050'-04010'N and longitudes 005030'005040E. It is fed by river Osun and has a surface area of more than 248km² and a maximum depth of 6m though a large area of lagoon is relatively shallow with a minimum depth of 1m, and mangrove swampy vegetation surroundings (Balogun, 1987).

Sample collection

The samples of *Elops lacerta* used were purchased from fishermen's catch at Epe lagoon, Lagos state for wet and dry season. The fish was placed in ice in an aseptically insulated ice bag and transported to the laboratory within few hours for analysis.

Fillet Yield procedure

Fillet yield was carried out according to Yenmark (2018) as modified by Okomoda *et al.*, (2020).

Proximate composition determination

The proximate composition of fish was determined following AOAC (2000). Samples were analyzed in triplicates.

Determination of mineral elements

The mineral elements were determined according to Almoaruf *et al.* (2003).

Determination of Vitamins

Determination of vitamins were carried out, using Brubacher *et al.*, (1985) and AOAC (2011) standards.

Data analysis

Data for the experiment were subjected to one way analyses of variance (ANOVA) and express in mean, standard deviation and bar chat. All statistical analysis were considered at significance level of 5% ($p < 0.05$).

Results and Discussion

Fillet Yield

Fillet yield recorded for the rainy season and dry seasons were 42.42 ± 0.15 and 35.62 ± 0.56 , respectively. The waste for rainy season was 7.36 ± 1.55 and 6.21 ± 1.42 for dry season. It has a low waste yield for both seasons with no significant difference but fillet yield was lower in the samples collected in dry season in this study. This could be due to the presence of full grown ovaries in the body, resulting in higher waste production in this season compared to rainy of the year (Hoseinzadeh- Sahafi, 2007). Proximate analysis indicates that there was no significant difference ($p < 0.05$) in crude protein content of *Elops lacerta* across the season which disagree with (Abdullahi 2001) who reported that the protein content in fish might vary with species due to certain factors such as the season of the year and effect of spawning. In analysis of mineral composition of the fish. It should be noted that even though sodium is important for muscle functions and electrolyte balancing, it is not usually a problem in mineral deficiencies as it is frequently used to salt food. Nitrogen and Iron is higher in dry season than wet season. The result obtained in this investigation (Table 3) testifies the specific differences of functioning of the systems that take part in support of acid-base balance of organisms, Sodium is also good for muscle functioning (Alas *et al.*, 2014). Vitamin composition for rainy season and dry season is not significantly different at ($p < 0.05$). it is therefore assumed that the composition of vitamins in *Elops lacerta* is not affected by season (Table 4).

Table 1: Table showing the fillet yield weight of fish samples during rainy season and dry season

Season	Weight of sample	Total length	Standard length	Weight of frame	Weight of head	Weight of fillet	Weight of gut
Rainy	68.78 ± 0.65	22.99 ± 0.2	17.84 ± 1.89	6.71 ± 1.56	12.79 ± 1.85	42.42 ± 0.15	2.63 ± 1.23
Dry	57.97 ± 0.58	21.73 ± 0.1	16.72 ± 1.54	5.59 ± 0.96	10.79 ± 2.01	35.62 ± 0.56	2.26 ± 1.3

Values are expressed in mean and standard deviation.

Table season 2. Proximate composition of samples grouped in rainy season and dry season

Seasons	%crude protein	%ash content	%ether extract	%crude Fibre	%moisture	%dry matter	NFEs
rainy	56.38 ± 1.16	3.42 ± 0.19	7.38 ± 0.1	0.01 ± 0	34.29 ± 1.96	65.76 ± 1.96	33.59 ± 1.86
dry	56.26 ± 1.17	7.11 ± 0.21	7.76 ± 0.22	0.01 ± 0	68.77 ± 1.49	31.11 ± 1.49	28.92 ± 1.60

Values are expressed in mean $\pm$ standard deviation

Table 3. Mineral composition of fish at rainy season and dry season

Season	Ca	Zn	K	Fe	P	Mn	Na	N
Rainy	257.63±0.67	3.33±0.11	332.54±0.92	5.65±0.001	352.13±4.56	5.63±0.12	131.99±0.09	8.94±0.06
Dry	210.33±20.70	1.38±0.53	256.25±26.80	9.45±1.34	243.18±48.67	5.45±0.62	84.98±22.18	9±0.27

Table 4: Vitamin composition of fish in rainy season and dry season

Season	vit A	vit B	vit C	vit D
Rainy	22.81±17	0.17±0.01	0.85±0.01	1.34±0.02
Dry	23.09±0.52	0.18±0.01	0.91±0.04	1.32±0.01

Conclusion and Recommendation

The studies of the proximate composition revealed that the fish sample for both seasons are rich in protein and are good sources of minerals. The study also shows that there is little variation in the proximate composition of *Elops lacerta* in the two seasons. It is therefore, recommended that seasonal variations on the proximate, mineral and vitamin composition of other fish species should be investigated.

References

- Abdullahi, S.A. (2001). Nutritional Evaluation of three species of the fish family Mochokidae.(*Synodontis membranaceus*, *Synodontis melanopterus* and *Synodontis filamentosus* From Northern Nigeria. *Niger. J. Sci. Res.*, 8, 48-51.
- Abdullahi, S.A, Abolude, D.S., Ega, R.A. (2010). Nutrient quality of four oven dried fresh water catfish species in Northern Nigeria. *Journal of Tropical Biosciences*1 (1):70-76.
- Alam, A.K.M.N., Mohanty, B.P., Hoq, M.E., Thilsted, S.H., 2012. Nutritional values,consumption and utilization of Hilsa *Tenuulosa ilisha* (Hamilton 1822). In :Proceedings of the Regional Workshop on Hilsa: Potential for Aquaculture, 16–17 September 2012, Dhaka, Bangladesh.
- Alas, R., Kaarelson, T., & Rees, C. (2014). The Impact of Social, Political and Economic Changes on People Management in Estonian Organizations. *Journal of Management and Change*, 32/33, 77-88
- AOAC. Official Methods of Analysis of AOAC International. 18th Edition, Revision 4, In: W. Horwitz and G.W. Jr. Latimer (Eds.), AOAC International: Gaithersburg, MA, USA, 2011.
- Association of Official Analytical chemistry (AOAC) (2000): *Official methods of analysis*, Association of Official Analytical Chemists, Vols I & II, Association of Analytical chemists, Arlington, pg128.
- Brubacher, G.B., Muller-Mulot, W., Southgate, D.A.T., (1985). Methods for the deter-mination of vitamins in food: recommended by COST, vol. 91. Elsevier Applied Science Publishers Ltd., London.Byrdwell,
- FAO Fisheries and Aquaculture Final Report, (2013), *Nutrient Profiling and Evaluation of Fish as a Dietary Component*, Central Institute of Freshwater aquaculture 22-23.
- Kopp, LangŠ.,BrabecT., Mares J. (2013): Influence of physicochemical parameters of water on plasma indices in brook trout (*Salvelinusfontinalis*Mitchill) reared under conditions of intensive aquaculture. *ActaVeterinariaBrno*.82 (40): 367-373.
- Okomoda VT, Tihamiyu LO, Ricketts AO, Oladimeji SA, Agbara A, Ikhwanuddin M, Alabi KI, Abol-Munafi AB. (2020).s Hydrothermal processing of *Clarias gariepinus* (Burchell, 1822) filets: Insights on the nutritive value and organoleptic parameters. *Journal of Veterinary Science* 7:133-141
- Yenmak S, Joerakate W, Poompuang S. (2018). Prediction of fillet yield in hatchery populations of Asian sea bass, *Lates calcarifer* (Bloch, 1790) using body weight and measurements. *International Aquatic Research* 10:253–261.

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Effect of Three Different Diets on Growth and Survival of Tilapia (*Oreochromis niloticus*) Culture in a Fibre Glass Tanks

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Abstract

The effect of three different diets on growth and survival of tilapia (*Oreochromis niloticus*) cultured in a Fibre Glass Tank was examined. Nine circular Fibre Glass Tanks of 3.08m³ capacities and depth of 60.5cm each and diameter 176.78cm were used in the experiment. The treatments were dried chicken manure only (treatment I), dried chicken manure with commercial diet (coppens) (treatment II) and commercial diet (coppens) only as control (treatment III). The results indicated significant differences in final weight gain among treatment I (143.47g), treatment II (171.97g) and treatment III (272.10g). Survival rate was highest for treatment III with 99.33%. Therefore, commercial diets with the addition of manure is recommended for the culturing of tilapia species.

Keywords: Growth, Survival, Tilapia, Culture systems.

Introduction

In Nigeria, tilapia production is predominantly an extensive land based (earthen ponds) system practised at subsistence levels (Fagbenro, 2002) while commercial tilapia culture is yet to become popular and widespread (Afolabi *et al.*, 2000), its current yield is 14,388 tone/year (Fagbenro and Adebayo, 2005). Tilapia ingest a wide variety of natural food organisms including plankton, some aquatic macrophytes, planktonic and benthic invertebrates, larval fish, detritus and decomposing organic matter (Popma and Masser, 1999). With heavy supplemental feeding, natural food organisms typically account for 30 to 50 percent of tilapia growth. Tilapia is often considered filter feeders because they can efficiently harvest plankton from the water. They are versatile feeder and farmed tilapia will accept prepared diet immediately after the initiation of feeding; the use of complete supplementary feeds or complete feed can accelerate growth by 5-10, thus increasing yields and shortening culture time (Harley, 1990).

The nutritional quality both of commercially manufactured fish feeds produced on-site by fish farmers, depend on the quality of feed ingredients used (Nalwanga *et al.*, 2009). Since the quality of complete feeds depends on the quality of ingredients (Glencross *et al.*, 2007; Lie *et al.*, 2006; Aksnes and Mundheim, 1997), the nutrient content of feed ingredients should be seen as a starting point for any attempt at improving feed quality at the production level (Nalwanga *et al.*, 2009).

Craig and Helfrich (2002) reported that the sustenance and expansion of tilapia production is limited by the high cost of fish feeds, which comprise over 50% of the production costs.

According to Tacon (1993), protein is usually the most expensive nutrient and its level and quality determine the cost of fish feeds. In addition, most fish feeds contain a proportion of animal protein, which is considered superior to other sources in terms of palatability and nutrient availability (Tacon, 1993). Growth of Nile tilapia (*O. niloticus*) is primarily dependent on the absolute protein intake (g protein kg⁻¹ day⁻¹) (Tacon and Cowey, 1985; Bowen, 1987) rather than on the dietary protein level (Yakupitiyage, 1989). There have been several reviews of the nutrition and feeding of tilapia in commercial operations (Ulloa, 1995; Diana, 1997; Lim, 1997; El-Sayed, 2006). Early tilapia production systems relied on natural food organisms as the source for nutrition (Lim and Webster, 2006). These early production systems were extensive in nature. As the industry expands and the technology development continues, traditional extensive culture of tilapia is being replaced by semi intensive and intensive production systems. In semi-intensive farming systems, supplemental feeds that consist of locally available, low-cost single feedstuffs, such as rice bran, copra meal, coffee pulp, brewery by-products and/or their combination, are generally used as supplements to natural food (Lim, 1989). Several factors including fish size or age, dietary protein source, energy content, water quality and culture conditions have been reported to affect protein requirements of tilapia (NRC, 1993).

The escalating price of fish feed necessitate alternative means of feeding fish hence this study aimed at comparing the effect of two low cost diets with commercial diet on growth and survival of tilapia (*Oreochromis niloticus*) culture in a fibre glass tank.

Materials and Method

The study was conducted at the Nigerian Institute for Oceanography and Marine Research Sapele out station Sapele Local Government Area of Delta State, Nigeria (N50 54'.5''E005°39'56.4').

Nine circularfibreglass tanks were used in the experiment. All experimental tanks were identical in shape and size. Tanks capacities were 3.08m³ and depth of 60.5cm each and diameter 176.78cm. The tanks were washed and disinfected with salt solution before water was introduced into the tanks from treated bore hole in the station. Sex reversed Nile tilapia (*Oreochromis niloticus*) of 0.80g average size was stocked. The tanks were divided into three culture systems that is intensive culture, semi intensive culture and extensive culture in triplicates for each culture system. The treatments were dried chicken manure only, dried chicken manure plus commercial diet (coppens) and commercial diet (coppens) only as control. These treatments were used to determine the dissolved oxygen dynamics in each culture system and to predict the effect of other water quality parameters on dissolved oxygen in the treatment tanks. Three hundred (300) fish were stocked in each tank.

The fish used for this experiment were fingerlings of all male Nile tilapia (*O. niloticus*). Fish were fed at 800hr and 1600hr with dried chicken manure, chicken manure plus commercial feed (coppens) and commercial feed only (coppens). The feeding rate was 5% of the total fish biomass and the feeding rate was adjusted every two weeks. The adjustment was done by calculating the average weight of the fish sample, multiply by the total biomass express in percentage.

Random samples of 75 fish were taken biweekly from each treated tank during the experimental period. Analysis of crude protein, crude fibre, ether extracts, ash and moisture content were done for the chicken manure and the commercial diet (Coppens) following AOAC (1990) procedures

Seventy five (75) fish which is 25% of the fish stocked in each tank were randomly sampled biweekly from each treatment tank and weighed in a weighing balance during the experimental period. From the measurements, the following parameters were determined:

Initial weight of Fish in gram (g)

Final weight of fish harvested (g)

$$Bi-weeklymeanweightgain(g) = \frac{Totalbi-weeklyweight(g)}{Total\ No\ of\ fish\ weight\ (g)} \quad (1)$$

$$Absolute growth rate\ (g/day) = \frac{Final\ weight - Initial\ weight\ of\ fish}{Culture\ period(days)} \quad (2)$$

$$Specificgrowthrate(SGR\% \ day) = 100 \times \frac{(\ln Finalbodyweight - \ln Initialbody\ weight)}{Rearing\ period\ in\ days(t)} \quad (3)$$

where

ln = natural log

$$Feed\ Conversion\ Ratio = \frac{Total\ weight\ of\ feed\ consumed}{Total\ weight\ of\ fish\ produced} \quad (4)$$

$$Fish\ Survival\ Rate(SR\%) = \frac{Total\ fish\ number\ harvested}{Total\ fish\ number\ stocked} \times 100 \quad (5)$$

$$\text{Fish Yield} = \frac{\text{Total weight of fish harvested over culture}}{(g / 180 \text{ days} / 3.08 \text{ m}^3)} \times 100 \quad (6)$$

Statistical Analysis

The data was collated and was subjected to One-way analysis of variance (ANOVA). Standard deviation was calculated to identify the range of means and error respectively. Least Significance difference (LSD) was used to determine the level of significance at the probability of 5% among treatments using SPSS 16.0 Statistical Packages for Windows 2000.

Results and Discussion

Using equation 1, the mean weight gain in treatment I was found to be 42.49 while that of treatment II recorded was 55.77 and treatment III was 108.91. Fish in treatment III showed the highest mean weight gain of 108.91 which was significantly different from all the other treatments (Table 1). Fish in treatment I and II recorded 42.49 and 55.77 respectively, which were not significantly different from each other.

Table 1: Values of bi-weekly mean weight gain Of All male tilapia *O niloticus* fed with three different types of feed

Weeks	Chicken Only (g)	Manure With Coppens (g)	Coppens Only (g)
2	0.83	0.77	0.80
4	1.07	1.39	1.98
6	4.50	6.63	15.53
8	9.14	13.64	33.17
10	14.05	20.55	51.57
12	19.74	27.84	72.09
14	26.57	35.79	103.81
16	40.38	58.04	135.35
18	59.38	85.04	174.63
20	79.27	107.67	206.73
22	111.48	139.87	239.10
24	143.47	172.97	272.10
Mean	42.49 ^b	55.77 ^b	108.9 ^a

Table 2 below further show that there were significant differences in final weight gain between the three feed types, treatment I (143.47g), treatment II (171.97g) and treatment III (272.10g).. The highest final mean weight gain of 272.10g was recorded in treatment III that was fed with coppens only, followed by treatment II with final mean weight gain of 171.97 fed with chicken manure with coppens and the least final mean weight gain of 143 47 was observed in treatment I fed with chicken manure only. In general, final mean weight increased and performed better with treatment that were fed with coppens only.

The average value of Specific growth rate ranges between 4.96 in treatment I, 5.14 in treatment II and 5.60 in treatment III as shown in table 3, this was estimated using equation 3. However, the differences in Specific Growth Rate values between the different experimental treatment were not far from each other hence are not significant.

Survival rate exceeded 90% in all treatments. Treatment I recorded 77%; treatment II 99% and treatment III 99.33% which is the highest survival rate. Table 3 gives the values and this was estimated using equation 5.

There was a significant difference in feed intake among the treatments. Feed intake increased progressively from a low intake of 584.5g for treatment I to 823.70g in treatment II and a high feed intake of 1596.30g for treatment III by measurement. Furthermore, the data indicated that at a similar stocking density fish fed with chicken manure

only consumed significantly less feed than those fed with chicken manure withcoppens and coppens only as shown in Table 3.

Table 3: Growth performance of all male Tilapia fed with chicken manure only, chicken manure with coppens and coppens only in a fibre glass tanks

Parameters	Treatments		
	I (Chicken manure only)	II (Chicken manure with coppens)	III (Coppens only)
Initial mean weight (g)	0.83	0.77	0.80
Mean weight gain (g)	42.49 ^b	55.77 ^b	108.91 ^a
Final mean weight (g)	143.47 ^c	171.97 ^b	272.10 ^a
Specific growth rate (%/day)	4.96 ^a	5.14 ^a	5.60 ^a
Survival rate (%)	77 ^a	99 ^a	99.33 ^a
Feed intake (g feed/fish)	584.50 ^c	823.70 ^b	1596.30 ^a
Feed Conversion Ratio	1.95	2.75	5.32

Mean with different superscripts in the same row are significantly different

There was a significant difference in the size of the fish at harvest among the treatments ($P < 0.05$). Treatment III showed the largest size of 272.1g (Table 3). This was followed by treatments II (172.07g) and treatment I with 143.47g respectively. The general pattern was that at similar stocking density, Treatment that received Coppens only performed better than those that was fed with Chicken manure withcoppens and Chicken manure only. There was no significant difference in mean biomass among the treatments ($P > 0.05$). The highest mean biomass of 27.2kg was recorded in treatment III whereas the lowest mean biomass 14.3kg was observed in Treatment I and 17.207 in treatment II. Mean biomass generally increase with the feed type in the treatment that received Coppens only than treatment that received Chicken manure withcoppens and Chicken manure only as diet. (Table 3).

Table 3: Number of biomass (kg) and mean size (g) of All Male Tilapia *O. niloticus* stocked and harvested in each treatment.

Treatment	Number	Stocking Mean Biomass (kg)	Mean size (g)	Number	Harvest Mean Biomass (kg)	Mean size (g)
Chicken manure only	900	0.83*	2.49	831	14.347*	143.47
Chicken manure with coppens	900	0.77	2.31	897	17.207*	172.07
Coppens only	900	0.82*	2.46	898	27.210*	272.10

Conclusion

The study has been able to discover that the fish in treatment III grows better than treatment II which in the normal case of Treatment II supposed to grow better because of the fertilizer that will decompose and form phytoplankton and zooplankton as extra food for the fish to grow.

References

- Abdel M. T., Abdel H.M. Eld, Ali E. A., Hany I E.(2005). Assessment of water quality and primarily productivity in earthen fishponds stocked with stripped mullet (*MugilCephalus*) and subjected to different feeding regimes.
- Afolabi, J. A., Imoudu, P. B. and Fagbenro, O. A. (2000). Urban tilapia culture in homestead concrete tanks: economic and technical viability in Nigeria. Pages 575 – 581.
- Boyd, C. E. (2002): Guidelines for aquaculture effluent management at the farmlevel. *Aquaculture*, 226:101-112. Boyd C. E. (2002). Farm- level issues in Aquaculture certification; *Tilapia*.
- Craig, S. and Helfrich, L.A. (2002). Understanding fish Nutrition, Feeds and Feeding. Cooperative Extension Service Publication.Pp.220-256. Virginia State University, USA.
- Diana, J.S. (1997). Feeding strategies. In: Egna, H.S., Boyd, C.E. (Eds.), *Dynamics of pond aquaculture*. CRC Press, Boca Raton, Florida, pp. 245–262.
- El-Sayed, A-F.2006.*Tilapia Culture* CABI Publications, Wallingford, UK. 275pp.Hand
- Fagbenro, O.A. 2002. *Tilapia: fish for thought*. 32nd Inaugural Lecture, Federal University of Technology, Akure, Nigeria. 77pp
- Fagbenro, O.A.& Adebayo, O.T.(2005) A review of the animal and aquafeed industries in Nigeria. In: A synthesis of the formulated animal and aquafeed industry in sub-Saharan Africa, pp.25-36. (John Moel& Matthias Halwart, editors). CIFA Occasional Paper No.26, FAO, Rome. 61pp.
- Glencross, B.D., Booth, M., and Allan, G.L. (2007). A feed is only good as its ingredients – a review of ingredient evaluation strategies for aquaculture feeds. *Aquacult. Nutr.* 13: 17 – 34.
- Gross A., C. Boyd, and C.W. Wood (2000). Nitrogen transformations and balance in channel catfish ponds. *Aquacultural Engineering* 24:1-14
- Lim, C. (1997). Nutrition and feeding of tilapias.in: Alston, D.E., Green, B.E. and Clifford, H.C. (Eds.), IV Symposium on Aquaculture in Central America. AsociacionNacional de Acuicultoresde Honduras and the Latin American Chapter of the World Aquaculture Society, pp. 94-107.
- Lim, C. (1989). Practical feeding – Tilapias, in: Lovell, R.T. (Ed.), *Nutrition and Feeding of Fish*. Van Nostrand Reinhold, New York, USA, pp. 163-183.
- Lim, C.E. and Webster, C.D. (2006). Nutrient requirements In: Lim, C.E. and Webster, C.D. (Eds.), *Tilapia: Biology, Culture and Nutrition*. Food Products Press, New York, USA, pp. 469-501.
- Nalwanga, R., Liti, D.M., Waidbacher, H., Munguti, J., and Zollitsch, W.J. (2009). Monitoring the nutritional value of feed components for aquaculture along the supply chain – an East African case study. *Livestock Res. Rural Dev.* 21(9): 20 – 34.
- Popma, T, and Masser, M. (1999). *Tilapia Life History and Biology* Southern Regional Aquaculture Center, SRAC Publication No. 283.
- Tacon, A.G.J. (1993). Feed ingredients for warm water fish: fish meal and other processed feedstuffs. FAO Fisheries Circular No. 856, Rome.
- Tacon, A.G.T. and Cowey, C.B. (1985).Protein and amino acid requirements. In: *Fish Energetics-New Perspectives* (ed. by P. Tyler and P. Calow). John Hopkins University Press, Baltimore, MD, USA.pp.155-184.

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Yield and Proximate Composition of Farmed African Fresh Water Catfish (*Clarias gariepinus*)*Ezekiel M.O.¹, Salaudeen M.M.¹, Olusola A.O.¹ and Adeyemi R. S.¹¹Department of Fish Technology and Product Development, Nigerian Institute for Oceanography and Marine Research. P. M. B. 12729, Victoria Island, Lagos, Nigeria*Correspondence: kachiezekiel@yahoo.co.uk +2348081484948**Abstract**

The potential increase in the production of African catfish (*Clarias gariepinus*) demands for market expansion for the fish, therefore it is essential to provide information on the development of fillet production, a value added products from catfish. Catfish samples were obtained from a commercial farm and transported to NIOMR Fish Technology processing laboratory. The morphometric measurements were taken and the proximate composition was determined. The skinned fillet yield was 34% while the other 66% was waste from the fillet process of which heads and frames contributed 31.2% and 17% respectively. The guts and skin contributed 10.4% while slime and drip loss 3.2% and mince 4.2%. The results from proximate composition indicated the presence of crude protein ($17.12 \pm 0.12\%$), lipid ($3.39 \pm 0.78\%$), carbohydrate ($0.75 \pm 0.00\%$) and moisture ($77.2 \pm 0.69\%$). These findings provide scientific bases for further utilization of this specie.

Key words: Fillet yield, Farmed catfish, protein, Lipid, Moisture

Introduction

In 2019 aquaculture contributed 26% out of 1,114,556ton estimated Nigeria fishery production (FAOSTAT, 2020). Farmed African catfish (*Clarias gariepinus*) production has increased dramatically in the recent years, total production in Nigeria jumped from 7.8% to 53.2% in 2001 and 2013 respectively (Daude *et al* 2018). With the potential and promise of further increases in production, it is essential to provide information on the development of techniques for fillet production, a value added products from catfish, to further enhance its market expansion. The high demand for convenience foods in Nigeria which are presently coming in as imported products has created a large market for deboned fish. Fillets are now getting popular in the country as they are now convenient for housewife to cook with no further preparation.

Many fish species are filleted to satisfy consumer and market demands. It is also important for the addition of value along the marketing chain and for the separation of the edible parts from inedible ones (Aderson *et al*, 1994). The most important factor in the profitability of value-added fish production (aside from selling price) is usually the yield of the finished product. However, the processor is left with a lot waste to get rid of (carcass) which therefore necessitates charging higher price for the fillets. Cost of raw material represents the largest percentage of total costs. It is also necessary to understand how processing procedures affect the interrelationship between yields, throughout and final profitability. The processing yield of various fish species depends almost entirely on the shape of the fish, the size of the head and the amount of meat that can be extracted from the usable flesh (Rora *et al*, 2001).

The knowledge of proximate composition is also very important. Information on protein, oil, ash and moisture content is needed for effective utilisation while processors and consumers have direct interest in the composition and safety of the fish product they consume. The present work examined the yield of skinned fillet and the proximate composition of African catfish (*Clarias gariepinus*) with the view to developing sustainable processing method for farmed catfish fillet.

Materials and Method

Freshly harvested live catfish were obtained from a commercial farm in Lagos. Twenty six samples, weighing 25kg were collected and transported to NIOMR Fish Technology processing laboratory. The morphological characterisation of the fish was done prior to processing. The measurements taken were weight(kg) for all samples using top loading weighing scale (OHAUS® Pioneer™), total body length (cm), standard length and head length for each sample using standard graduated fish measuring board.

Catfish Fillet Processing

Figure 1 shows the flow chart for the catfish filleting process. The fish upon receipt were sorted and weighed. Stunning of the fish was done using some quantity of food grade common salt (NaCl), 5 per cent (w/w) which was sprinkled on the fish in closed plastic container and allowed to stay for 10 minutes. The fishes were cleaned and slime removed manually by dipping in water containing 3.5% aluminium sulphate (w/v) and the skin gently robbed to remove the slime and some adhering particles. Cleaned fish were removed and placed on clean plastic cutting board.

Using stainless steel filleting knife, the fish were headed and gutted manually. Filleting and skinning of fillet were done manually using the knife. The skinned fillet was washed in clean sterile water, allowed to drain and manually vacuum packed in transparent low density polyethylene (LDPE) bag using table top vacuum sealer. Storage of the packaged fillet was done and stored in a chest freezer operating at temperature of -20°C. Plate 1 shows the skinless catfish fillet.

Yield Analysis

The yield at each processing stage was determined by weighing the respective output using a top loading weighing balance. The frame was further processed by passing it through a Baader® 694 (Lubeck, FRG) belt and drum flesh-bone separator with 5mm drum perforations to recover the mince from the frame. The mince obtained was weighed and yield determined. The percentage yield output at each processing stage was determined by expressing the respective weight as the rate of the weight of raw whole fish before processing multiply by 100. Thus the yield of the skinned fillet was determined according to equation (1).

$$\% Y_{\text{fillet}} = \frac{W_{\text{fillet}}}{W_{\text{fish}}} \times 100 \quad \dots\dots\dots(1)$$

The weight of fluid (the blood, slime and drippings) from the fish was determined by difference according to equation (2)

$$W_{\text{fluids}} = W_{\text{fish}} - (W_{\text{fillet}} + W_{\text{head}} + W_{\text{frame}} + W_{\text{guts}} + W_{\text{mince}}) \quad \dots\dots\dots(2)$$

From equations (1) and (2); Y_{fillet} is the yield of the skinned fillet. W_{fillet} , W_{fish} , W_{fluids} , W_{head} , W_{frame} , W_{guts} , W_{mince} are the weights of the skinned fillet, raw whole fish (as received from farm), fluids (including blood, slime and drippings) from the fish, head (and gills), frame (including fins and bones only, no head), guts (and skin) and mince (recovered from the frame and trimmings).

Proximate analysis of the skinned fillet: Catfish fillets, freshly prepared (before freezing) were analysed for moisture, crude fat, crude protein, ash and carbohydrate according to AOAC, (2005).

Crude protein was determined by Kjeldahl procedure using nitrogen factor of 6.25 (Pearson, 1981), total lipid by (Bligh and Dyer, 1959) method, moisture content by oven drying at 103±2°C and ash by incineration in a muffle furnace at 525°C. Carbohydrate was determined by difference between the total dry sum of ash, protein, crude fat, and fiber subtracted from 100.

$$\text{Carbohydrate} = 100 - (\% \text{ Ash} + \% \text{ moisture} + \% \text{ Crude lipid} + \% \text{ Crude protein}) \dots\dots\dots(3)$$

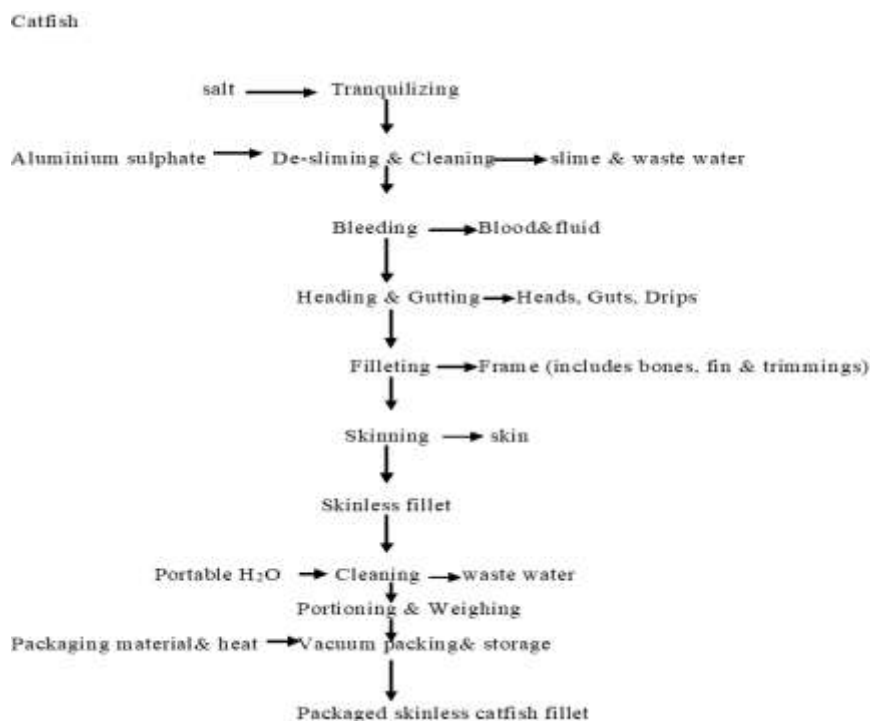


Figure 1: Flow chart for Catfish (*Clarias gariepinus*) filleting process

Results and Discussion

The morphological feature of the catfish used for the production of fillet is shown in Table 1. The total weight for all samples measured together was 25kg.

Table 1: Morphological feature of the farmed Catfish (*Clarias gariepinus*).

Parameters	Mean ^a	Range
Total Body weight (kg)	0.96±0.09	0.9 - 1.2
Total length (cm)	51±1.66	48 - 55.5
Standard length (cm)	41.7±1.6	38.4 - 45.3
Head length (cm)	11.8±0.75	10.5 - 13.5
Total weight for all fish samples (kg) ^b	25.	

^aValues are mean of 26 measurements

^bvalue is the weight of the 26 fish samples measured together

The data for the weight and yield of the catfish filleting process is presented in Table 2. The yield of the skinned fillet, the primary product is 34% of the whole catfish. This shows that 66% are processing byproducts or waste from catfish filleting process of which heads and frames contributes 31.2% and 17% respectively. The guts and skin, 10.4% while slime and drip loss constitute 3.2% and mince, 4.2%. The yield of the fillet is less than 40% which could be attributed to large head structure. Yield is also a function of quality of the fish. Studies on technological properties of Bonga (*Ethmalosa fimbriata*) fish have shown that those with large head relative to the muscle produce smaller yield and vice versa (Akande and Faturoti, 2005). The low yield could also be attributed to manual filleting efficiency which is a function of the dexterity of the processor.

The flesh-bone separation process produced 1.05kg of mince representing 19.81% of frame and trimmings.

Table 2: Weight and yield of catfish filleting process

Yield indices	Weight (kg)	Yield^a%
Whole fish	25	100
Skinless fillet	8.5	34
Heads	7.8	31.2
Frame	4.25	17
Guts, skin	2.6	10.4
Slime and drip loss	0.8	3.2
Mince from frame	1.05	4.2

^aExpressed as percentage of the weight of whole fish



Plate 1: Skinless catfish (*Clarias gariepinus*) fillets prepared, Vacuum packed and frozen

Considering the effect of yield on the catfish filleting process; at the purchase price of the raw catfish of ₦25000.00 at ₦1000 per kg and only 34% of fillet as the primary product, the cost of the skinless fillet without any fixed or variable costs is ₦76, 500 at ₦9000 per kg. This amounts to an increase of 206% of the buying price of the whole fish. However, additional money can be realised by conversion of the waste to fishmeal and adding value to the mince.

The proximate composition of the fillet is shown in Table 3. This shows that the fillet is low in lipid and high in protein (Han *et al*, 2019). The average values of constituents obtained are not in agreement with the published data for farmed catfish fillet (skin-on) (Obany *et al.*, 2016) 72.8%, 30.86%, 8.4% for moisture, protein and lipid respectively. This variation might be due to the presence of skin, feed and environmental conditions in which the fish sample was subjected prior to processing.

Table 3: Proximate composition of farm raised African freshwater Catfish fillet

Constituent	fillet)
Moisture	77.2 ± 0.69
Protein	17.12 ±0.12
Lipid	3.39 ± 0.78
Ash	1.53 ± 0.12
Carbohydrate	0.75 ± 0.00
Mean± standard deviation	

Conclusion

The yield of fillet was 34% of the whole fish while 66% accounted for the by-products, of which 61.8% can be converted to fishmeal and 4.2% to mince. The effect of yield on filleting process showed an increase of 206% on the cost of buying raw whole fish excluding any fixed or variable costs. The proximate composition of catfish fillet indicated a good nutritional value (high percent moisture, high protein, low fat product).

References

- Akande, G.R and Fatureti, O.E, (2005). Technological properties and biochemical studies of Bonga :*Ethmalosa fimbriata*. *Fishery Technology*, 42(1) : 61-66.
- AOAC 2005, Association of Official Analytical Chemist, Official Methods of Analysis.18th Edition, AOAC International, Suite 500, 481 North Frederick Avenue, Gaithersburg, Maryland 20877-2417, USA.
- Bligh, E. G., and Dyer, W. J. (1959).A rapid method of total lipid extraction and purification. *Can. J. Biochem. Physiol.* 37, 911–917.
- FAOSTAT, 2020 The Food and Agricultural organization of the United Nations.The state of world fisheries and Aquaculture. <http://www.fao.org/3/ca9229en/ca9229en.pdf>
- FDF 2007: Federal Department of Fisheries. Fisheries Statistics of Nigeria, 4th Ed.: 1995-2007. 49pp
- Han Y., Hao H., Yang L., Chen G., Wen Y. and Huang R. 2019 Nutritional characteristics of marine fish *SardinellazunasiBleeker* and immunostimulatory activities of its glycoprotein
- Obany O. D., Asaad H. M., Agib M. A, El- faki F. E, Ali M. E (2016) Comparative studies on nutritive value of wild and farmed African catfish *Clariasgariepinus**International Journal of Fisheries and AquaticStudies*; 4(3): 327-329
- Pearson, D (1981): The Chemical Analysis of Food. Churchill livingstone, Edinburgh, 504-530.
- Rørå, A. M. B., T. Mørkøre, and O. Einen (2001).Primary processing (Evisceration and Filleting), pp. 249–260. In: Farmed Fish Quality (Kestin, S. C., and Warriss, P. D., Eds.). 1st ed. Oxford: Fishing News Books

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Catfish (*Clarias gariepinus*) Roe: A valorize resource***Mutiat Motolani Salaudeen¹, Martha Onyekachi Ezekiel¹ and Meriyamoh Mero Onimisi²**¹Nigerian Institute for Oceanography and Marine Research, PMB 12729, Victoria Island, Lagos²Department of Fisheries and Aquaculture, Kogi State University, Anyigba, Kogi State.*Correspondence author: salaudeenmm@niomr.gov.ng, salaudeen06@yahoo.com**Abstract**

Up to 80% wastes and by-products could be generated from fish processing activities; by-products can be used to develop functional products of positive health, economic and environmental impacts. The nutritional composition and acceptability of smoke-dried, oven dried and spiced catfish roe were determined. The protein, lipid and moisture contents of all treatments ranged between (55.04±0.0 - 55.70±0.0) %, (15.13±0.0 - 15.41±0.0) % and (3.90 ±0.0 - 3.92±0.0) % respectively. The calcium, iron, magnesium, zinc and phosphorus contents of all treatments ranged between (5.00±0.0 - 5.07±0.1), (44.18±0.0 - 44.25±0.1), (18.30±0.1 - 18.59±0.2), (11.14±0.1 - 11.20±0.1) and (477.42±10.0 - 481.80±4.0) mg/100g dry weight respectively. The oil of the dried catfish roe was found to be rich in polyunsaturated fatty acids while the cholesterol levels ranged between (800.96±1.8 - 822.90±3.5) mg/100g dried weight. All the dried catfish roe products are nutritious and were well-accepted by the sensory panellists. The developed products constitute healthy foods that can be used as spice, condiment, thickener and source of nutrients in children diet.

Keywords: Catfish roe, Smoke-dried, Spiced and Oven-dried, Nutritional Composition, Sensory Attributes

Introduction

There is a strong demand for fish products due to increasing consumer awareness of the nutritional benefits of fish (Diouf, 2009) and a source of high quality food (Abeywardena and Patten, 2011; Dyck *et al.*, 2011) recommended as a means of preventing cardiovascular and other diseases (Alasalvar *et al.* 2011; Cruz Casallas *et al.*, 2012). Protein rich food is necessary for growth and repair of body cells, increase protein intake improves gain in muscle mass and strength in adults (Wirth *et al.*, 2020). Food rich in minerals are needed for body growth and development. They are needed to live long and stay healthy and their deficiency can lead to disorders and disease symptoms (Gharibzadeh and Jafari, 2017).

Omega-3 and omega-6 fatty acids are unsaturated essential fats that must be derived from diet. They have important benefits for the heart, brain and metabolism (Connor, 2000) and (Ruxton *et al.*, 2007). The body needs a small quantity of cholesterol to build the structure of cell membranes and proper body metabolism (Sonal *et al.*, 2020). Fish roe (eggs) and other by-products could be derived from catfish processing and value addition activities such as filleting, drying, smoking and canning. To maximise profits, wealth creation and to save the environment, it is very important to make use of fisheries wastes and under-utilized fisheries resources as by-products for functional products that are nutritious and of health benefits.

Materials and Method**Collection and preparation of catfish roe**

A sample of 5kg catfish roe was collected during the smoke-drying of 120kg catfish as wastes (by-products) from Fish Technology and Product Development pilot plant of Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos. The roe was rinsed with clean water, soaked in 3% brine solution for 10mins. The brined roe was then divided into five parts of 1kg each. The divided brined roe were subjected to the following treatments
T1 = Catfish roe in 3% brine solution for 10mins, smoke-dried with NIOMR improved kiln and pulverized into powder, packed in plastic bottles and labelled.

T2 = Catfish roe in 3% brine solution for 10mins oven-dried at 50°C, pulverized into powder, packed in plastic bottles and labelled.

T3 = Catfish roe in 3% brine solution for 10mins + 5% ginger (*Zingiberofficinale*) and oven-dried at 50°C, pulverized into powder, packed in plastic bottles and labelled.

T4 = Catfish roe in 3% brine solution for 10mins + 5% onion (*Allium cepa*) and oven-dried at 50°C, pulverized into powder, packed in plastic bottles and labelled.

T5 = Catfish roe in 3% brine solution for 10mins + 5% turmeric (*Curcuma longa*) and oven-dried at 50°C, pulverized into powder, packed in plastic bottles and labelled.

Proximate analysis

Protein

Protein was determined in triplicate by Kjeldahl method using Foss KjeltexTM 2100. There were three steps involved: Digestion, distillation and titration. A gram of well homogenised sample was weighed in the digestion tube and digested by 12 ml of concentrated sulphuric acid (H₂SO₄) in the presence of selenium catalyst. The digestion tubes were placed in the digestion block and digested at a temperature of 420 °C for one hour. After digestion, 75mls of distilled water was added to each tube prior to distillation. Each tube was placed in the distillation column and distilled with 50mls of 40% sodium hydroxide (NaOH) solution. The reaction product was rendered alkaline, while the liberated ammonia was received in the conical flask with boric acid and then titrated with 0.1 N hydrochloric acids (ISO, 2005).

Lipids

Lipid content was determined in triplicate by Bligh and Dyer (1959) with slight modification of breaking up the lipids with N-hexane.

Moisture

Moisture content was determined by difference in weight of the homogenised samples before and after drying for 24hr in an electronic oven at a temperature of 104± 2 °C (AOAC, 1994).

Mineral determination

Wet digestion of the sample was done and the minerals were identified and quantified with the use of Atomic Absorption Spectroscopy (AAS) and as described by AOAC, 2004 and EPA 7000A and B, (1990).

Fatty acids composition

The fatty acid composition of the total lipids extract was determined by gas chromatography of fatty acid methyl esters (FAMES). The methylation of fatty acids was carried out according to American Oil Chemists Society (AOCS) 1998. Lipid content was determined by Bligh and Dyer (1959) The FAMES were separated on a Varian 3900 GC equipped with a fused silica capillary column (HP-88, 100 m x 0.25 mm x 0.20 µm film, Agilent Technologies), split injector and flame ionisation detector fitted with Galaxie Chromatography Data System. This programme was based on the AOAC 996.06 (2001).

Cholesterol determination

The total cholesterol was determined by AOAC, (2010), official method 994.10, cholesterol in foods.

Sensory analysis

Twenty (20) trained panellists who are familiar with and usually include fish products in their diet made judgement on the appearance, taste, flavour and overall acceptability of the dried catfish roe products. The sensory analysis was done using the following points: Like extremely (9), Like very much (8), Like moderately (7), Like slightly (6), Neither Like nor Dislike (5), Dislike slightly (4), Dislike moderately (3), Dislike very much (2), Dislike extremely (1). The sensory panellists were selected by the procedure described by Meilgaard *et al.* (2006) with slight modification.

Results and Discussion

Proximate composition of catfish roe

Table 1: Proximate composition of dried catfish roe (%)

Treatment	Protein	Lipid	Moisture
T1	55.70±0.04 ^d	15.41±0.03 ^c	3.90±0.02 ^a
T2	55.51±0.15 ^c	15.32±0.12 ^c	3.92±0.01 ^a
T3	55.24±0.13 ^b	15.24±0.02 ^{ab}	3.91±0.01 ^a
T4	55.07±0.07 ^{ab}	15.17±0.04 ^a	3.90±0.00 ^a
T5	55.04±0.02 ^a	15.13±0.03 ^a	3.92±0.02 ^a

^{a-d} Different superscripts within the same column indicate significant differences at $p < 0.05$

Crude protein formed the largest quantity of the dry matter in all the dried catfish roe products, followed by the total lipids and the moisture content ranged between 3.90% and 3.92%. Fish eggs have substantial food value. On a dry basis, eggs contain 45-48% protein and 11-32% lipids (Motohiro, 2003). The crude protein content of the dried roe products makes the roe products good source of protein.

Moisture content is a determinant of the quality of dried food products and dried fish of 15% or less moisture is known to inhibit microbial growth (Clucas, 1982). The developed roe products can be stored without refrigeration due to the low moisture contents of 3.92%.

Mineral composition of dried catfish roe

Table 2: Mineral composition of dried catfish roe (mg/100g dry weight)

Treatment	Calcium	Iron	Magnesium	Zinc	Phosphorus
T1	5.06±0.06 ^a	44.19±0.02 ^a	18.50±0.01 ^{ab}	11.19±0.13 ^a	481.80±4.04 ^a
T2	5.04±0.06 ^a	44.18±0.06 ^a	18.59±0.20 ^b	11.14±0.11 ^a	477.42±10.01 ^a
T3	5.00±0.03 ^a	44.22±0.10 ^a	18.31±0.13 ^a	11.18±0.02 ^a	481.07±2.17 ^a
T4	5.04±0.02 ^a	44.25±0.13 ^a	18.55±0.09 ^b	11.20±0.10 ^a	479.49±4.96 ^a
T5	5.07±0.06 ^a	44.19±0.04 ^a	18.43±0.05 ^{ab}	11.19±0.16 ^a	480.75±1.99 ^a

^{a-ab} Different superscripts within the same column indicate significant differences at $P < 0.05$

The dried roe products are good sources of minerals such as calcium, iron, magnesium, zinc and phosphorus (Table 2). Deficiency of iron in the diet can affect the rate at which the body make use of energy (Abbaspouret *et al.*, 2014). Absence of calcium, magnesium in diet might result in weak, stunted growth and poor bone development (WHO, 1996; Gharibzahedi and Jafari, 2017). Zinc is an essential metal for the normal functioning of various enzyme systems. Its deficiency, particularly in children can lead to loss of appetite, growth retardation, weakness and even stagnation of sexual growth (Saracogluet *et al.*, 2009). According to Food and Agriculture Organization (FAO) food balance data, it has been calculated that about 20% of the world's population could be at risk of zinc deficiency (FAO, 2001). The developed roe products are rich in zinc and this could contribute significantly to dietary zinc intake since zinc from animal source foods is highly bioavailable (FAO and WHO, 2004). The roe products are rich in phosphorus which is needed in bones and teeth formation. It helps the body to utilise carbohydrate and fats and make protein for growth (NIH, 2021).

Fatty acids composition of dried catfish roe

The fatty acids composition of dried catfish roe is presented in Table 3.

Table 3: Fatty acids composition of dried catfish roe oil

Fatty acids composition (%)	Mean $\pm$ SD
Total fatty acids composition	98.04 $\pm$ 1.05
Saturated fatty acids (SFA)	41.54 $\pm$ 0.95
Monounsaturated fatty acids (MUFA)	34.05 $\pm$ 0.55
Polyunsaturated fatty acids (PUFA)	22.44 $\pm$ 0.55
PUFA/SFA	0.54
Eicosapentaenoic EPA	0.12 $\pm$ 0.02
Docosahexaenoic DHA	0.68 $\pm$ 0.09
Σ EPA + DHA	0.80 $\pm$ 0.10
n-3 (Omega- 3 fatty acids)	5.70 $\pm$ 0.15
n-6 (Omega-6 fatty acids)	16.74 $\pm$ 0.35
n-6/n-3	2.9: 1

SD = Standard Deviation.

Values in red are some indices for measurement of oil quality: WHO, 2005 (n-6/-n-3 $\leq$ 5:1), (PUFA/SFA $>$ 0.4); HMSO, 2001 (n-6/-n-3 $\leq$ 4:1)

The roe products are rich in fatty acids composition, the ratios of omega-6 to omega-3 and polyunsaturated fatty acids to saturated fatty acids fall within the acceptable limits by WHO, 2005. The ratio of omega-6 to omega-3 in modern diets is approximately 15:1, whereas ratios of 2:1 to 4:1 have been associated with reduced mortality from cardiovascular disease, suppressed inflammation in patients with rheumatoid arthritis, and decreased risk of breast cancer (HMSO, 2001; Martin et al., 2006).

Cholesterol of dried catfish roe

The total cholesterol of the dried roe products is presented in Figure 1. The dried roe products with natural antioxidants, ginger, onion and turmeric have significantly low cholesterol levels.

There is increasing interest in dietary cholesterol due to the connection of plasma cholesterol levels with the risk of cardiovascular diseases. (Zhong, *et al.* 2019; Zhuang, *et al.*, 2021). It has been reported that between 20-25% of the cholesterol in the body comes from the food of animal origin such as egg, Zhuang, *et al.*, 2021). It is therefore necessary to know the concentration of cholesterol in our diet to prevent cardiovascular diseases. The body needs about 300 mg dietary cholesterol per day and an individual should eat moderately dietary cholesterol for proper body metabolism (Clayton, *et. al.*, 2017).

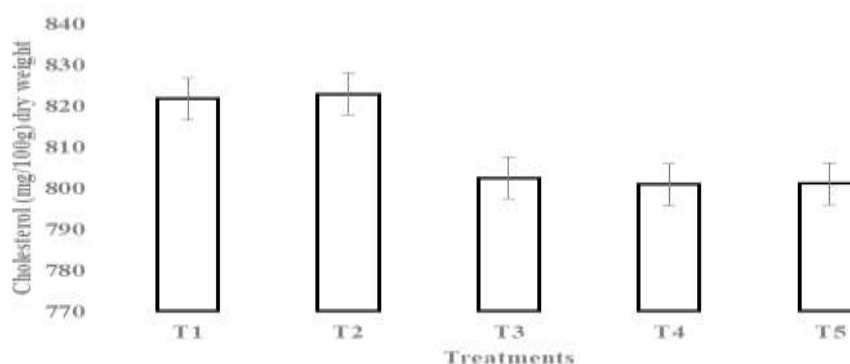


Figure 1: Cholesterol levels of dried catfish roe

Sensory attributes of dried catfish roe

The results of the sensorial analysis, demonstrating preference criteria like appearance, taste, flavour and overall acceptability for the dried catfish roe products are presented in Table 4.

Table 4: Sensory attributes of dried catfish roe

Treatment	Appearance	Taste	Flavour	Overall acceptability
T1	7.14±1.88	7.00±1.45	7.24±1.73	7.29±1.76
T2	7.10±1.52	6.65±1.57	6.50±1.86	7.15±1.53
T3	7.60±1.10	7.40±1.39	7.35±1.23	7.60±1.10
T4	7.70±1.17	7.40±1.04	7.45±1.10	7.60±0.94
T5	7.00±1.21	6.60±1.47	6.85±1.14	6.80±1.28

The results showed high level of acceptability of all the products. Considering overall acceptability, the panellists preferred treatments 3 (dried catfish roe spiced with ginger) and 4 (dried catfish roe spiced with onion) but there was no significant difference ($P>0.05$) among the products in all the parameters tested.

Conclusion

It was observed that appreciable percentage of roe (eggs) and other by-products could be derived from catfish processing and value addition activities such as filleting, drying, smoking and canning. The study indicated that all the dried catfish roe products are well accepted by the panellists and are good sources of protein, minerals and lipids which are excellent in polyunsaturated fatty acids. The dried catfish roe products treated with natural antioxidants, ginger, onion and turmeric have low total cholesterol levels. The PUFA: SFA and n-3: n-6 ratios of the dried catfish roe products are within the recommended value by WHO, thus constituting healthy foods that can be used as spice, condiment, thickener and source of nutrients in children diet.

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References

- Abbaspour, N., Hurrell, R. & Kelishadi, R., 2014. Review on iron and its importance for human health. *Journal of Research in Medical Sciences*, 19(2), 164-174.
- Abeywardena, M.Y. & Patten, G. S., 2011. Role of omega-3 long chain polyunsaturated fatty acid in reducing cardio-metabolic risk factors, *Endocrine, Metabolic and Immune Disorders Drug Targets* 11(3), 232-246.
- Alasalvar, C., Shahidi, F., Miyashita, K. & Wanasundara, U., 2011. *Handbook of seafood quality, safety and health applications*. United Kingdom: Wiley-Blackwell. 535pp.
- AOAC, 2010. *Official Methods of Analysis of the Association of Official Analytical Chemists*, official methods 994.10, cholesterol in foods, 18th Edition, Washington DC, USA.
- AOAC, 2004. *Official Methods of Analysis of the Association of Official Analytical Chemists*, 18th Edition, Washington DC, USA.
- AOAC, 2001. Fat (Total, Saturated, Unsaturated) in food. *Hydrolytic Extraction Gas Chromatographic Method*, Official method Ce 996.06. 2200+pp.
- AOAC, 1994. *Official Methods of Analysis of the Association of Official Analytical Chemists*, Vols. I & II, Association of Analytical Chemists, Arlington. 1298pp.
- AOCS, 1998. *Official method and recommended practices of the American Oil Chemists Society*. In Firestone, D. (Ed), Official method Ce 1b-89. Champaign, IL, 1200pp.
- Clayton, Z. S., Fusco, E., & Kern, M., 2017. Egg consumption and heart health: a review, *Nutrition*, 37, 79-85.
- Clucas, I. J., 1982. *Fish handling, processing and preservation in the tropics*, Tropical Products Institute, London.
- Connor, W. E., 2000. The importance of n-3 fatty acids in health and disease. *American Journal of Clinical Nutrition*, 71, 171S- 175S.
- Cruz Casallas, N. E., Cruz Casallas, P. E. & Suarez Mehecha, H., 2012. Characterization of the nutritional quality of the meat in some species of catfish: A review. *Revista Facultad Nacional de Agronomía Medellín*, 65(2), 6799-6809.
- Bligh, E. G. & Dyer, W. J., 1959. "A rapid method of total lipid extraction and purification". *Canadian Journal of Biochemistry and Physiology*, 37, 911-917.

- Diouf, J. 2009. How to feed the world in 2050. FAO's Director-General's Statements, [http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How](http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_feed_the_world_in_2050.pdf) to feed the world in 2050. 35 p.
- Dyck, M. C., Ma, D. W. & Meckling, K. A., 2011. The anticancer effect of vitamin D and omega-3 PUFAs in combination via cod-liver oil: one plus may equal more than two. *Medical Hypotheses*, 77(3), 326-332.
- EPA, 1990. Environmental Protection Agency methods 7000A&B for metals and mineral analysis, USA pp.
- FAO, 2001. A handbook of food balance sheets, Food and Agriculture Organization, Rome, 2001. Reprinted, 2008. 95pp.
- FAO/WHO, 2004. Vitamin and mineral requirements in human nutrition: Report of a joint FAO/WHO expert consultation, Geneva, Switzerland.
- FAO/WHO, 2001. Food additives and contaminants. Joint Codex Alimentarius Commission.
- Gharibzahedi, S. M. T. & Jafari, S. M., 2017. The importance of minerals in human nutrition: Bioavailability, food fortification, processing effects and nanoencapsulation. *Trends in Food Science and Technology*, 62, 119-132.
- HMSO, 2001. Her Majesty's Stationery Office. Report on Health and Social Subjects, Department of Health Nutritional Aspects of Cardiovascular Disease. London, 45, 37- 46.
- ISO, 2005. Method for analysing protein in fish and fishmeal. International Standard, ISO 5983-2:2005.
- Meilgaard, M., Civille, G. V., & Carr, B. T., 2006. Sensory Evaluation Techniques. Boston London: CRC Press, Inc. 464pp.
- Motohiro, T., 2003. Fish: Miscellaneous Fish Products. Encyclopaedia of Food Science and Nutrition. Second edition. 6000pp.
- NIH, 2021. Medline Plus, United States National Library of Medicine, National Institute of Health updated 02 July, 2021, accessed, 10 August, 2021.
- Ruxton, C. H., Reed, S. C., Simpson, M. J. & Millington, K. J., 2007. The health benefits of omega-3 polyunsaturated fatty acids: a review of the evidence, *Journal of Human Nutrition and Diet*, 20, 275-285
- Saracoglu, S., Tuzen, M. & Soylak, M., 2009. Evaluation of trace element contents of dried apricot samples from turkey. *Journal of Hazardous Materials*, 156, 647-652.
- Sekhar, S., Marupuru, S., Reddy, B. S., Jacob, S. & Rao, M., 2020. Physiological role of cholesterol in human body. In: Dietary Sugar, Salt and Fat in human health, Pp 453-481.
- WHO, 1996. Trace Elements in Human Nutrition and Health. World Health Organization, Geneva, 1996.
- WHO, 2005. Avoiding heart attacks and strokes. World Health Organization, Geneva, Switzerland. 32pp.
- Wirth, J., Hillesleim, E. & Brennan, L., 2020. The role of protein intake and its timing on body composition and muscle function in healthy adults: systematic review and meta-analysis of randomized controlled trials. *The Journal of Nutrition*, 150(6), 1443-1460.
- Zhong, V. W., Horn, L. V., Cornelis, M. C., Wilkins, J. T., Ning, H., Greenland, P., Mentz, R. J., Tucker, K. L., Zhao, L., Norwood, A. F., Lloyd-Jones, D. M. & Allen, N. B., 2019. Association of dietary cholesterol or egg consumption with incident of cardiovascular disease and mortality. *Journal of the American Medical Association*, 19, 321(11), 1081-1095.
- Zhuang, P., Wu, F., Mao, L., Zhu, F., Zhang, Y., Chen, X., Jiao, J., & Zhang, Y., 2021. Egg and cholesterol consumption and mortality from cardiovascular and different causes in the United States: A population based cohort study. *Public Library of Science Med.*, 18(2), e1003508.

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Proximate and Mineral Composition of Shrimp (*Peneaus notialis*) from Lagos Lagoon, Nigeria**Ukazu, E.R., Uzoalu, I.J., Egbe, F.C., Esangbedo R. and M.O.Awoyale**

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Abstract

The proximate and mineral composition of *Peneaus notialis* from Lagos Lagoon, Nigeria was determined. Chemical analysis was done in triplicates using standard laboratory methods. The results obtained indicated that the proximate content of the specie were: Protein, 18.84%, crude fat 1.23%, ash 1.73% moisture 71.63%, crude fibre 1.69% and carbohydrate 4.86%. The mineral values of the specie was high especially that of potassium (114.86mg/100g), calcium (214.18mg/100g) and sodium (139.60mg/100g). Others are Phosphorus (27.33mg/100g), Zinc (24.12mg/100g) iron (35.54mg/100g), magnesium (14.18mg/100g) and manganese (0.8mg/100g). In conclusion. *P. notialis* is a good source of protein which can be used for feed formulation and consumed by humans. They also contain considerable amounts of minerals and are low in fat.

Keywords: Proximate composition, mineral composition, *Peneaus notialis*

Introduction

Shellfish is a fisheries and culinary term for exoskeleton-bearing aquatic invertebrates used as food. They can be divided into two groups namely; molluscs and crustaceans. Familiar marine molluscs enjoyed as a food source by humans include many species of clams, mussels, oysters, winkles and scallops. Some crustaceans commonly eaten are shrimps, prawns, lobsters, crayfish and crabs (Ehigiator & Oterai 2012).

Fish is consumed by a large percentage of population in the world due to its high quality protein. It contains the most important nutritional components and serves as a source of energy for human beings. (Ojewola and Annah, 2006). Majority of the nutrition lists recommend that human beings should consume fish every day (Blanche, 2000). Regular consumption of fish can reduce the risk of cancer, including colon, breast and prostate (Sidhu, 2003), lower the risk of Dementia, and alzheimer's diseases and prevent the cardiovascular diseases (Cahu *et. al* 2004).

Knowledge of proximate composition such as protein contents, carbohydrates, lipids, moisture contents and ash percentage is often necessary to ensure that they meet the requirements of food regulations and commercial specifications (Watermann, 2000). Generally, composition of live-weight, whole fish is 70 to 80% moisture, 20 to 30% protein, and 2 to 12% lipid (Love, 1980). However, in different environmental conditions, the composition of the fish may differ in relation to the differences in water quality, feeding conditions, sex, state of maturity and capture condition (Eyo, 2001).

Moreover, the study of mineral elements present in living organisms is of biological importance; since many of such elements take part in some metabolic processes and are known to be indispensable to all living things (Shul'man, 1974). The body usually contains small amount of these minerals, some of which are essential nutrients, been components of many enzymes system and metabolic mechanisms, and as such contribute to the growth of the fish. (Fawole *et al.*, 2007). The most important mineral salts are that of calcium, sodium, potassium, phosphorous, iron, chlorine while many others are also needed in trace amounts. The deficiency in these principal nutritional mineral elements induces a lot of malfunctioning; as it reduces productivity and causes diseases, such as inability of blood to clot, osteoporosis, anemia etc. (Shul'man, 1974 and Mills, 1980). Therefore, studies on the proximate composition and elemental composition of the marine fishes have not really caught attention of researches in fisheries; Hence the consumer and fishery workers are left with limited or paucity of information's on the importance of particular fish species in their daily diets (Adewoye *et al.*, 2003). This then assessed the proximate and mineral content of *P.notialis* from Lagos lagoon in Lagos State, Nigeria.

Materials and Method

Sample preparation: Samples of freshly caught shrimp, *Peneaus notialis* were purchased from local fisherman at Makoko landing site of Lagos lagoon. The samples were placed on ice and transported to the chemistry laboratory of Fish Technology Department, Nigerian Institute for Oceanography and Marine Research Victoria Island Lagos. Length and weight of 30 randomly selected *P. notialis* were measured. After the measurements were taken, the samples were thoroughly washed with distilled water and the shrimps were separated into exoskeleton (the head and the shell) and the endoskeleton (flesh). The fleshy part of the shrimp was homogenized using mortar and pestle. The homogenized sample was kept inside the refrigerator at 4°C prior to analysis.

Proximate analysis: Proximate analysis was carried out in triplicate determination on the homogenized sample of *P. notialis*. Moisture content was determined by drying the sample in an oven at 102-105°C and dried to constant weight following the method as described by AOAC, (2000). Ash content was determined by incineration of 5 g of the sample at 600°C for 8 h (AOAC, 2000). The determination of crude fat content was conducted by modified method of Bligh and Dyer (1959). Nitrogen was determined using the Kjeldahl method and the quantity of protein was calculated by multiplying the percentage nitrogen content by the conversion factor 6.25 (AOAC, 2000). The content of total carbohydrates was determined by anthrone method as described by Hedge, and Hofreiter, (1962) and crude fibre was determined using AOAC, (2000) method.

Determination of mineral elements: One gram of the sample was weighed into the digestion flask of 250 ml capacity a 25 ml of Nitric acid, perchloric and sulphuric acid was added to each sample. The flask was fixed to a clamp and kept overnight. When the initial reaction subsided, the temperature of the micro-digestion bench was increased slowly from 180°C to 200°C. The digestion was continued at that temperature until no visible particles observe, the temperature was raised up to 240°C and the digestion acid was evaporated until dense white fume formed within the digestion flask. After the digestion was completed, the content of the flask was filtered and the digested material was kept in a dust proof glass chamber. The samples were digested with the disappearance of brown fumes, diluted to 100ml for Atomic absorption spectroscopy (AAS) Analysis using suitable hollow cathode lamp.

Result and Discussion

Table I showed the result of the percentage mean proximate composition of *P. notialis*. The result showed encouragingly high crude protein content of 18.84%, crude fat 1.23%, ash (1.73%), moisture, (71.63%), crude fibre (1.69%) and carbohydrate (4.86%) The relatively high to moderate percentage crude protein could be attributed to the fact that; shrimps are good source of pure protein (Fawole *et al.*, 2007). The high protein content is important in the body as it helps in the replacement of worn out tissue and regulation of body metabolism. (Bello and Akinyele, 2007).

It was equally observed from the study that, the specie belonged to a lean fish group. Ackman, (1989), grouped fish species into four categories based on their fat content: lean fish (<2%), low fat (2-4%), medium fat (4-8%) and high fat (>8%). Shrimps are extremely good source of protein, yet they are low in fat making them a very healthy choice of food. Although shrimps have high cholesterol content, they are low in saturated fat, which is the fat that raises cholesterol levels in the body. (Omotosho *et al.*, 2011)

Ash is a measure of the mineral content of any food (Omotosho *et al.*, 2011). The ash content of the shrimp investigated was considerably high which will make it a good source of minerals.

Table II showed the result of mineral composition of *P. notialis* expressed in mg/100g. Calcium, sodium and potassium were found to be the major component followed by iron, phosphorous, zinc, magnesium and manganese in that order. The high levels of these elements in the sample studied may be attributed to the rate in which they are available in the water body and the ability of the fish to absorb them from their diet and the environment where they live.

The term fish quality is all encompassing and its study difficult owing to the fact that specific parameters that are recognized as being a virtue in one part of the world are judged to be less important elsewhere (Love, 1980). The ranges of values of the proximate composition and mineral contents of the *P. notialis* from the artisanal fishermen used in this study are within the ranges of values recorded for fin and shell fish as recorded by Job *et al.* (2015).

Similar ranges of both the proximate and mineral contents reported in this study have been reported by Love, (1980), Ackman, (1989) FAO (2010) and USDA (2010) of permissible limits for fish and fisheries product.

Table I. Proximate composition of *P. notialis* in %

Protein	18.84
Crude fat	1.23
Moisture	71.63
Ash	1.73
Crude fibre	1.69
CHO	4.86

Table II. Mineral composition of *P. notialis* in mg/100g

Ca	214.18
Fe	35.54
P	27.33
Mg	14.18
Zn	24.12
Na	139.6
Mn	0.8
K	114.86

Conclusion

In conclusion, the present work revealed that *P. notialis* is good source of protein; hence, they can be used as substitute for meat and finfish and for feed formulation for animals. Also, the specie can provide significant proportion of calcium, phosphorus, zinc, potassium and magnesium for important metabolic processes. The specie is low in fat and is considered to belong to a lean fish class group. They are also low in carbohydrates and fibre.

References

- Ackman R. G. (1989); Nutritional composition of fats in seafood's. *Progress in Food and Nutrition Science* 13: 161-289.
- Adewoye, S. O., Fawole, O. O. and Omotosho, J. S. (2003); Concentrations of selected elements in some fresh water fishes in Nigeria. *Science Focus* 4: 106-108.
- AOAC, (2000). Official methods of Analysis. 17th Edn., Association of Official Analytical chemist, Washington, DC.
- Bello, B. K. and Akinyele, B.J. (2007); Effect of fermentation on the microbiology and mineral composition of *Termitomyces robustus*. *International Journal of Biological Chemistry. U S A* 1 (4): 237 – 243.
- Blanchet C, Dewailly E, Ayotte P, Bruneau S, Receveur O, (2000); Contribution of selected traditional and market foods to the diet of Nunavik inuit women. *Can. J. Diet Pract Res* 61:50-59.
- Bligh EG, Dyer WJ: (1959); A rapid method of total lipid extraction and purification. *Can. J. Biochem Physiol*, 37: 911-917
- Cahu C., Salen E. and Lorgeril M. D. (2004) Farmed and wild fish in the prevention of cardiovascular diseases: Assessing possible differences in lipid nutritional values. *Nutr Metab CardiovasC Dis* 14: 34-41.
- Ehigiator F.A.R. & Oterai E.A. (2012). Chemical Composition And Amino Acid Profile Of A Caridean Prawn (*Macrobrachium Vollenhovenii*) From Ovia River And Tropical Periwinkle (*Tympanotonus Fuscatus*) From Benin River, Edo State, Nigeria. *IJRRAS* 11 (1) ; 162-167.
- Eyo, A. A., (2001); Fish processing Technology in the Tropics. University of Ilorin Press, Ilorin, Nigeria.
- FAO, (2010). Nutritional Elements of Food and Agricultural Organization Fish. Rome.
- Fawole, O. O., Ogundiran, M. A., Ayandiran, T. A. and Olagunju. F.O. (2007); Proximate and Mineral Composition in Some Selected Fresh Water Fishes in Nigeria. *Internet Journal of Food Safety*, Vol.9, 2007, p. 52-55.

- Job B. E., Antai E. E., Inyang-Etoh A. P., Ootogo G. A. and Ezekiel H. S. (2015); Proximate Composition and Mineral Contents of Cultured and Wild Tilapia (*Oreochromis niloticus*) (Pisces: Cichlidae) (Linnaeus, 1758). *Pakistan Journal of Nutrition* 14 (4): 195-200,
- Love R. M., (1980); The Chemical Biology of Fishes. Brown ME (Edn), Academic press. New York, USA.
- Nurjanah, Agoes M. J., Roni N., Suhana S., Nurzakiah and Siti K. (2012); Proximate, Nutrient and Mineral Composition of Cuttlefish (*Sepia recurvirostra*). *Advance Journal of Food Science and Technology* 4(4): 220-224, ISSN: 2042-4876
- Ojewola G. S and Annah S. I (2006); Nutritive and economic value of Danish fish meal, crayfish dust meal and shrimp waste meal inclusion in broiler diets. *Int J Poultry Sci* 5: 390-394.
- Omotosho OE, Oboh G, Iweala EEJ (2011); Comparative effects of local coagulants on the nutritive value, invitro multi enzyme protein digestibility and sensory properties of Wara cheese. *Int J Dairy Sci* 6: 58-65.
- Ravichandran S., Rameshkumar G. and Rosario Prince A. (2012); Biochemical Composition of Shell and Flesh of the Indian White Shrimp *Penaeus indicus* (H. milne Edwards 1837). *American-Eurasian Journal of Scientific Research* 4 (3): 191-194, 2009 ISSN 1818-6785
- Shul'man, G.E. (1974): Life cycle of fish: Physiology and Biochemistry, Halsted Press a division of John Wiley and Son Inc. N.Y. (1st Ed.) Pg 101-104.
- Sidhu KS (2003); Health benefits and potential risks related to consumption of fish or fish oil. *Regul Toxicol Pharmacol* 38: 336-344.
- USDA, (2010). United State Department of Agriculture, West Agricultural Research Service, National Nutrition. Data base for standard reference. Release, 23.. *Pak. J. Nutr.*, 11: 1087- Nutrition Laboratory.
- Waterman, J..J. (2000): Composition and Quality of Fish, Edinburgh, Torry Research Station.

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Mycoflora Associated With Fish Feeds Sold in Some Selected Cities in Southwest Nigeria**Sodeeq, A.T¹., Afolabi, F.T²., Adebayo-Tayo, B.C². and Olajuyigbe, O. O¹.**¹Department of Fish Technology and Products Development, Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos.²Department of Microbiology, University of Ibadan, Ibadan, Oyo State, Nigeria.

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Abstract

Mycoflora of fish feed samples purchased from different retailers and fish farms in Ibadan (Oyo State), Akure (Ondo State), Osogbo (Osun State), Ijebu Ode (Ogun State) and Ikorodu (Lagos State), were investigated. A total of 17 samples made up of 51 fish feed samples were collected. The total fungi count ranged from 2.0×10^1 – 3.0×10^3 cfu/g. The moisture content and the pH was between 1.45 – 11.85% and 6.77 – 7.64 respectively. In conclusion, fish feeds bought from farms and retailers were heavily contaminated with moulds. A total of 35 fungal strains including *Alternaria* sp., *Aspergillus flavus*, *Aspergillus niger*, *Aspergillus tamarii*, *Aspergillus aculeatus*, *Cladosporium cladosporioides*, *Cladosporium sphaerospermum*, *Fusarium oxysporum*, *Fusarium compactum*, *Fusarium chlamydosporium*, *Penicillium chrysogenum*, and *Rhizopus* sp. were isolated from the samples.

Keywords: Fish feeds, Moulds, Southwest**Introduction**

Moulds are multicellular fungi that form hyphae, a thin-like structure. They are widely distributed wherever moisture is present (Adejumo and Adejoro, 2014; Richard, 2007). Fungi are a major spoilage organism of foods and feedstuffs because they thrive at very low water activity, a_w . The proliferation of various fungi in agricultural products leads to a reduction in yield and quality with significant economic losses (Adejumo and Adejoro, 2014; Bankole, 1994; Bayman and Baker, 2006; Richard, 2007). They produce secondary metabolites which are referred to as mycotoxins which have been found to be present in most food substances. The Presence of mould in fish feeds indicates contamination probably due to improper selection of ingredients for manufacturing or inadequate storage. Mould increase over a temperature range of 10-40 °C, pH range of 4-8 and humidity levels greater than 62% as well as more than 12-13% moisture (Doerr *et al.*, 1982).

Materials and Methods

Sample Collection: Finished fish feeds were purchased from farmers and retail stands in five different states of southwestern Nigeria, labelled correctly and transported to the microbiology laboratory of the fish technology and products development, NIOMR, Lagos for processing.

Determination pH and Moisture content: The pH values were obtained using pH while moisture content was determined using the method of Love, 1975.

Isolation and Characterization of Fungi Associated with the Samples: Isolation of fungi from the fish feed samples were made on sterile Potato Dextrose Agar (PDA) using the dilution method. Fungal isolates were identified based on their morphological and cultural characteristics as recommended by Domsch and Gams (1980) and Singh *et al.* (1991).

Identification of fungal isolates: The identification of the isolated fungi recovered from the examined fish feedstuffs included the macroscopic and microscopic examination. The identification of mould genera and species was carried out (Raper and Fennel, 1965; Samson, 1979) for genus *Aspergillus* and (Raper and Thom, 1969; Samson *et al.*, 1976; Zycha *et al.*, 1969) for the other mould genera. The microscopic examination of fungal colonies was carried out using both the wet mount slide method and the micro slide culture technique (Samson *et al.*, 1976).

Results

Table 1: Total Fungal Counts from the samples

Cities	TFC (-1)	TFC (-3)
Akure	1.1	3.0
Ibadan	2.0	1.0
Ijebu Ode	7.0	2.0
Lagos	7.0	2.0
Osogbo	1.1	3.0

TFC= Total Fungal Count

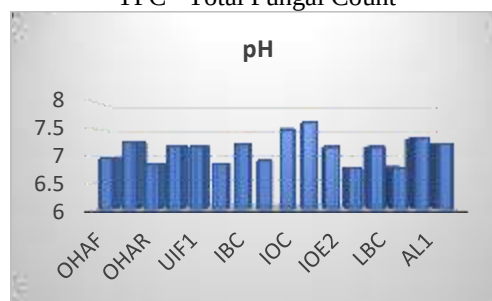


FIG 1: Hydrogen ion concentration of the samples.

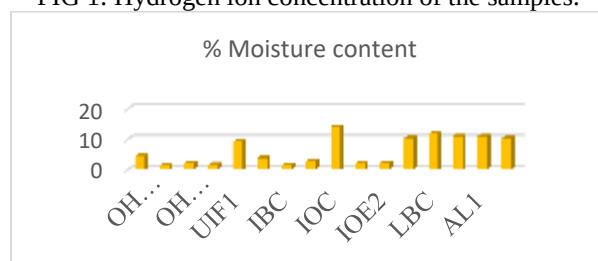


Fig. 2: % Moisture content of the fish feed samples

Table 2: Percentage Distribution of the Fungal Isolate from the fish feed samples

Isolates identity	number of occurrence	% occurrence
<i>Aspergillus flavus</i>	8	23
<i>Aspergillus niger</i>	7	20
<i>Rhizopus stolonifer</i>	5	14
<i>Aspergillus tamarii</i>	3	9
<i>Fusarium oxysporum</i>	3	9
<i>Cladosporium sphaerospermum</i>	2	5
<i>Alternaria sp.</i>	2	5
<i>Penicillium crysogenum</i>	1	3
<i>Fusarium sacchari</i>	1	3
<i>Aspergillus aculeatus</i>	1	3
<i>Cladosporium cladosporoides</i>	1	3
TOTAL	35	100

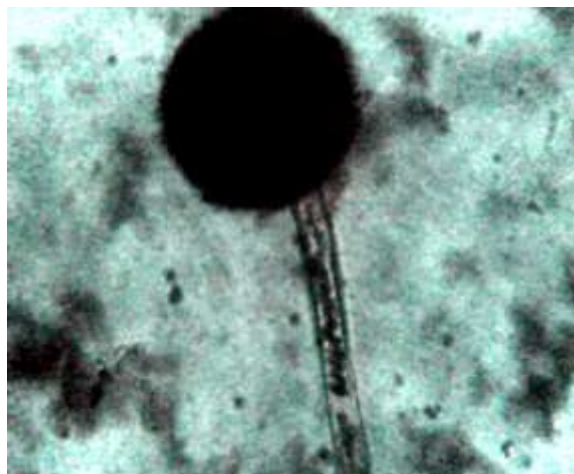


Fig. 4: Micrographic representation of *Aspergillus niger* x400

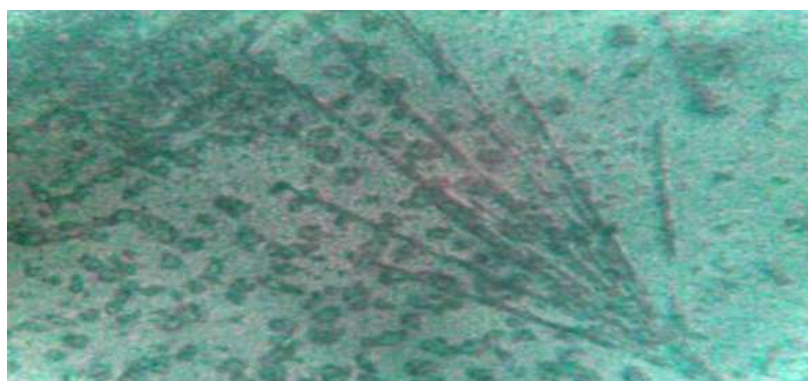


Fig. 5: Micrographic representation of *Alternaria* spp. x400

Discussion

Figure 1 shows the frequency of occurrence of the isolates in which *Aspergillus niger* had the highest frequency of occurrence (23%), followed in order by *Aspergillus flavus* (20%), *Rhizopus* sp. (14%), *Fusarium oxysporum* (9%), *Aspergillus tamarii* (9%), *Alternaria* sp. (5%), *Cladosporium sphaerospermum* (5%), *Penicillium citrinum* (3%), *Penicillium crysogenum* (3%), *Fusarium sacchari* (3%), *Aspergillus aculeatus* (3%) and *Cladosporium cladosporoides* (3%) respectively. Figure 2 shows the moisture content and figure 3-5 shows some photomicrographs of thr4 fungal isolates.

Table 1 shows the fungal count where samples from Ijebu Ode and Ibadan had the highest fungal contamination. These genera isolated from the fish feed samples agree with some other researchers such as Irene *et al.*, 2020; Adebayo-Tayo *et al.*, 2015; Jonathan *et al.*, 2013; Kana *et al.*, 2013; Oladejo and Adebayo-Tayo 2011; Somorin and Bankole 2010; Adebayo-Tayo *et al.*, 2008, who isolated similar organisms from smoked-dried frog, smoked-dried fish, dried meats, rice, 'garri', and peanut meal and maize.

Conclusion

Most fish feeds sold in some major cities in the South Western states of the country are contaminated with mycotoxigenic fungi and mycotoxins which is of public health concern. Proper processing of the feeds should start from the selection of the ingredients up to the storage. If all these can be perfected, the incidence of mycoses in fishes and humans will be greatly reduced if not completely wiped out.

Acknowledgement

To all those who contributed to the success of this work, you are all appreciated and acknowledged.

References

- Adebayo-Tayo B.C., Onilude, A.A., Patrick, U.G. Mycofloral of Smoked-Dried Fishes Sold in Uyo, Eastern Nigeria. *World J. Agricul. Sci.*, 2008;4:3, 346-350.
- Adejumo, T. O., Adejoro, D. O. Incidence of aflatoxins, fumonisins, trichothecenes and ochratoxins in Nigerian foods and possible intervention strategies. *Food Science and Quality Management*, 2014, 31, 127–146.
- Alocilja, E.C. and Radke, S.M. Market analysis of biosensors for food safety. *Biosensors and Bioelectronics* 2003; **18**, 841–846.
- Alvindia, D.G.; Acda, A.M. Mycoflora of coffee beans in the Philippines. *Int. Soc. Southeast Asian Agric. Sci.* **2010**, 16, 116–125.
- Bayman, P., & Baker, J. L. Ochratoxins: A global perspective. *Mycopathologia*, 2006, 162, 215–223.
- Doerr JA, Campbell JML, Huff W E. Interaction between dietary citrinin and Ochratoxin A in broiler chickens. *PoultScL* 1982; 61: 1453.
- Food and Agricultural Organisation (FAO), *The State of World Fisheries and Aquaculture*, Food and Agricultural Organisation (FAO), Rome, Italy, 2016.
- Gruber-Dorninger, C.; Jenkins, T.; Schatzmayr, G. Multi-mycotoxin screening of feed and feed raw materials from Africa. *World Mycotoxin Journal*, **2018**, 11, 369–38

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Impact of Processed *Jatropha curcas* Seed Meal (Jcsm) on Reproduction and Growth Performance of *Oreochromis niloticus* Juveniles

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Abstract

The impact of processed *Jatropha curcas* seed meal (JCSM) on reproduction and growth performance of *Oreochromis niloticus* juveniles was investigated for eight weeks using five dietary treatments (D1, D2, D3, D4 and D5) with different inclusion levels of processed (soaked and toasted) JCSM. A total of 300 *Oreochromis niloticus* juveniles were used for the study in a 5 x 3 completely randomized design (CRD). The study revealed that processed *Jatropha curcas* seed meal at both 2% and 4% inclusions were able to avert reproduction in *Oreochromis niloticus* juvenile for 8 weeks. The best reproduction control effects were observed at 4% inclusions for toasted and soaked JCSM with the soaked group performing better than the toasted group. The highest significant growth performance ($P < 0.05$) of juvenile *Oreochromis niloticus* with respect to FBW, BWG and SGR (75.42g, 45.76g and 4.28% day⁻¹ fish⁻¹ respectively) were observed in the fish fed diet (D1). From the study, it can be concluded that 2% and 4% inclusion levels of processed JCSM can be tolerated by *Oreochromis niloticus* juvenile for 8 weeks and no spawning activities but there was no improvement on their growth performance over the control.

Keywords: Tilapia, Reproduction, Phytoestrogens, *Jatropha curcas*, Growth

Introduction

The use of synthetic chemical hormones has a lot of associated problems such as bureaucratic impediments and cost of obtaining hormones for sex reversal, expertise requirements to handle the hormone and other problems such as environmental and public health concerns (Nwangwu *et al.*, 2015). These have been identified as some of the major reasons for the low popularity of commercial tilapia culture in Nigeria. There is also, a global concern of the residual effect of synthetic steroids on the fish flesh, producers, consumers and the environment (Dauda *et al.*, 2014). Generally, the existing methods to produce monosex (all-male) tilapia population encompass technical limitations that make them inappropriate for small aquaculture farms hence the need to explore affordable, environmentally friendly and appropriate alternative technology. This has led to search for alternative approaches including the use of natural reproduction inhibitors found in plants (Ugoala *et al.*, 2014) and phytoestrogenic plants with anti-fertility properties have also been thought of as a solution since they can be easily obtained and incorporated in tilapia feed (Dauda *et al.*, 2014).

Materials and methods

The study was conducted at the Hatchery Complex of the National Institute for Freshwater Fisheries Research (NIFFR), New Bussa, Niger State, Nigeria. Mature seeds of *Jatropha curcas* were prepared using two simple methods of detoxification i.e. toasting and soaking (48 hours) to obtain the processed *Jatropha curcas* seed meal (JCSM). A total of 300 pure strains of sexually mature and healthy *Oreochromis niloticus* juveniles were selected, sexed, acclimatized and twenty fishes were stocked in each 2m x 2m x 1m concrete tanks with male to female ratio of 1:3 in triplicates per treatment of 5 x 3 Completely Randomized Design.

Based on Nile tilapia nutritional requirements and ascertained proximate compositions of JCSM, Five (5) isonitrogenous dietary treatments (D1, D2, D3, D4 & D5) were formulated at 35% CP and used for the study. A control diet (D1) with zero (0) gram *Jatropha curcas* seed meal and four test diets (D2, D3, D4 and D5) with *Jatropha curcas* seed meal incorporated into the basal diet at 2%, 4% of toasted and soaked respectively to replace the GNC, Maize meal and Soybeans meal portion of the control. Fishes were fed at 5% body weight and sampling

was carried out fortnightly. Observations were made while feeding and sampling to know if spawning have occurred in any of the experimental tanks. During the period water quality parameters were monitored and recorded. From the data collated during the experimental duration, growth performance was evaluated. The growth parameters used were specific growth rate (SGR), body weight gain (BWG) and final body weight (FBW). The survival rate (SR) and Fulton condition factor (FCF) were equally determined using the following formulas as previously used by Workagegn *et al.* (2013) –

- ✓ BWG (grams per fish) = [(FBW - IBW) ÷ IBW];
- ✓ SGR (% per day per fish) = [(lnFBW - lnIBW) ÷ Dt] × 100;
- ✓ FCF = BWG (gm) ÷ TL (cm)³ × 100;
- ✓ SR = (NFS - NDF) ÷ NSF × 100;

Where: IBW = Initial Body Weight; Dt = days experimental duration; TL = Total Length; NFS = Number of Fish Stocked and NDF = Number of Dead Fishes.

Using IBM SPSS® Statistics Ver. 20, data were subjected to one-way analysis of variance (ANOVA), the significance of differences ($P < 0.05$) between mean values were tested with Duncan multiple range test.

Results and Discussion

The results of proximate and phytochemical composition of *Jatropha curcas* seeds (processed and unprocessed) are presented in Table 4.1 and Table 4.2 respectively. The results showed that alkaloids were not present in processed seeds. Glycosides and oxalic acid were not present in the toasted seeds. The variations in processed seeds (soaked & toasted) can be attributed to the processing technique where high moisture content (8.33%) in the soaked seeds is likely due to absorption of water molecules and lower moisture content (4.92%) in toasted seeds implies loss of water content due to heat. Also for CP value of the processed seeds compared to the raw seeds, it could be as a result of hydrolysis during soaking which increases the crude protein content, while the increase in protein contents of toasted sample might be attributed to an increase in the free nitrogen content after toasting.

Table 4.1: Proximate composition of *Jatropha curcas* seeds (processed and unprocessed)

Sample	Moisture (%)	Ash (%)	C P (%)	C F (%)	C. Fat (%)	NFE (%)	Energy (K/Cals)
S – JC	8.33	2.30	28.00	3.29	49.35	8.73	591.07
T – JC	4.92	3.21	31.37	3.42	40.40	16.68	555.80
R – JC	7.45	2.42	25.93	3.09	42.50	18.61	560.66

Where: S-JC = Soaked *Jatropha curcas*, T-JC = Toasted *Jatropha curcas*, R-JC = Raw *Jatropha curcas*, CP = Crude Protein, CF = Crude Fibre, C. Fat = Crude Fat and NFE = Nitrogen Free Extracts

Table 4.2.: Phytochemical constituents of *Jatropha curcas* seeds (processed and unprocessed)

Samples	Saponins	Phenols	Tannins	Glycosides	Oxalic acid	Alkaloids	Flavonoids
S – JC	++	++	++	+	+	-	++
T – JC	+	+	+	-	-	-	+
R – JC	++	++	++	++	++	+	+

Where: S-JC = Soaked *Jatropha curcas*, T-JC = Toasted *Jatropha curcas*, R-JC = Raw *Jatropha curcas*, “-” = Not Present, “+” = Present and “++” = Highly Present

The effects of processed JCSM as a sterility agent or reproductive inhibitor in juvenile Nile tilapia was evaluated based on visual observations at feeding and sampling periods. Fry were seen in the experimental tanks holding fishes that were fed control diets (D1) from 3 weeks into the experimental period and no fry was seen in all the tanks where fishes fed with processed (toasted and soaked) *Jatropha curcas* seed meal. However, eggs were seen in some of the treatment tanks on the last sampling day and a female fish in the 2% toasted treatment was seen to be mouth brooding. The study suggests that reproductions of *Oreochromis niloticus* was suppressed in all treatments with processed *Jatropha curcas* seed meal (JCSM) while the control treatments had free reproductive activities as evident in batches of spawning which occurred in the control tanks during the study. Similar reports were given by other authors like Jegede, 2011, Abdelhak *et al.*, 2013; Omeje 2016 with *Carica papaya* as sterility-inducing agents adducing that dosages of phytoestrogens in the Pawpaw seed meal (PSM) were destructive to testes and ovary tissues. The suppression in reproduction can thus be attributed to the presence of one or more phytoestrogens in processed *Jatropha curcas* seed meal which can act as EDCs in fish. For instance Nur and Sabrina (2013) concluded

that *Jatropha curcas* has anti implantation effects on pregnancy of Sprague dawley rats during early gestation period while Nwangwu (2017) affirmed that both processed and unprocessed JCSM were able to inhibit reproduction in Nile tilapia after 12 weeks at 10% and 20% inclusion levels.

Growth performance of *Oreochromis niloticus* juveniles fed 0% (control), 2%, and 4% of toasted and soaked *Jatropha curcas* seed meal is presented in Table 4.4. The initial body weight of the fishes were not significantly different ($P>0.05$); thus, variations in performances of fish among treatment groups was as a result of the inclusion of JCSM. The highest significant growth performance ($P<0.05$) of juvenile *Oreochromis niloticus* were noticed in fish fed with control diet (D1) followed by the group of fish fed (D3) in terms of growth parameters. This can be attributed to the low content of anti-nutritional factors which may affect dietary taste as well as restricts nutrients availability in other experimental diets. However, the average FBW of the fish increased reasonably from the initial value across all dietary treatments. The results are in concurs with the works of Workagegn *et al.*, 2013 who adduced that higher concentration of anti-nutritional factors (ANFs) in feeds reduces nutrient availability, protein digestibility and minerals bioavailability especially Ca^{2+} and Fe^{2+} which in turn impairs growth performance of the fish.

Table 4.3: Growth performance of *Oreochromis niloticus* juveniles processed *Jatropha curcas* seed meal (JCSM) for eight weeks

Parameters	D1	D2	D3	D4	D5
IBW (g fish ⁻¹)	29.66 ^a ±3.38	29.66 ^a ±3.44	29.66 ^a ±4.13	29.66 ^a ±3.05	29.66 ^a ±3.28
IBL (cm fish ⁻¹)	9.73 ^a ±0.27	9.71 ^a ±0.11	9.77 ^a ±0.85	9.78 ^a ±0.30	9.60 ^a ±0.36
FBW (g fish ⁻¹)	75.42 ^d ±6.15	56.02 ^b ±2.61	62.86 ^c ±3.69	50.62 ^a ±5.39	51.42 ^a ±2.06
BWG (g fish ⁻¹)	45.76 ^d ±8.28	26.36 ^b ±3.31	33.20 ^c ±0.73	20.96 ^a ±2.86	21.76 ^a ±1.76
SGR (% day ⁻¹ fish ⁻¹)	4.28 ^a ±0.14	3.96 ^c ±0.13	4.09 ^b ±0.20	3.86 ^d ±0.20	3.87 ^d ±0.11

Values with the same superscript in the same row are not significantly different ($P > 0.05$).

Where: IBW = initial body weight, IBL = initial body length, FBW = final body weight, BWG = body weight gain, SGR = specific body weight

Conclusion

Processed (toasted and soaked) *Jatropha curcas* seed meal at both 2% and 4% were able to delay spawning in juvenile *Oreochromis niloticus* for 8 weeks and can be tolerated by *O. niloticus* juveniles without adverse effect on the health and overall well being of the fish even though the growth performance is not enhanced, owing to insufficiency of the simple processing methods (toasting and soaking) to completely remove or neutralize the toxic components in JCSM.

References

- Abdelhak M. E., Madkour F. F., Ibrahim M. A., Sharaf M. S., Sharaf M. M. and Mohammed, D.A, (2013). Effects of pawpaw, *Carica papaya* seeds meal on the productive performance and histological characters of gonads in Nile tilapia, *Oreochromis niloticus*. *Indian Journal of Applied Research*, 3 (12): 34 - 37.
- Dauda, A. B., Yakubu, S. O. and Oke, A. O. (2014). Curbing the menace of prolific breeding in "aquatic chicken" (Tilapia): A way out to improve fish production in Nigeria, *New York Science Journal*, 7 (4):112-118. (ISSN: 1554-0200).
- Doughari, J.H.; Human, I.S, Bennade, S. & Ndakidemi, P.A. (2009). Phytochemicals as chemotherapeutic agents and antioxidants: Possible solution to the control of antibiotic resistant verocytotoxin producing bacteria. *Journal of Medicinal Plants Research*, 3(11): 839-848.
- Jegede, T. (2011). Effects of *Aloe vera* (Liliaceae) on the gonad development in Nile tilapia (*Oreochromis niloticus*) (Linnaeus 1758). In: Fitzsimmons, K., & Liping, L (eds), *Proceedings of the 9th International symposiums on tilapia aquaculture*, 222-227 pp. Aquafish CRSP, Shanghai, China.
- Nur, A. A. and Sabrina, S. (2013). Anti implantation effects of *Jatropha curcas* crude oil when fed to pregnant Sprague dawley rats during the early gestation period; *Advances in Life Science and Technology*, ISSN 2224-7181 (Paper) ISSN 2225-062X Vol. 14.
- Nwangwu, D.C. (2017) Control of prolific reproduction in *Oreochromis niloticus* culture using *Jatropha curcas* seed meal. A thesis submitted to the Department of Water Resources, Aquaculture and Fisheries Technology, Federal University of Technology, Minna. 62 Pgs.

- Nwangwu, D. C., Yisa, M. and Bake, G. G. (2015). The potentials of phytoestrogenic plants in tilapia production – A mini review. *Proceedings of 30th Annual Conference of the Fisheries Society of Nigeria (FISON) Asaba*. No: 87, Pp. 357 - 360.
- Omeje, V. O. (2016). Effect of Pawpaw (*Carica papaya*) seed meal on the reproductive, endocrine and immune system of Mozambique tilapia (*Oreochromis mossambicus*). PhD thesis, 145 pp. Stellenbosch University, South Africa, <http://scholar.sun.ac.za>.
- Ugoala, E., Ndukwe, G. I., Ayo R. G. O. and Mustapha, B. (2014). Natural products and aquaculture development., *IOSR Journal of Pharmacy and Biological Sciences, (IOSR JPBS)* 9 (2): 70-82
- Workagegn, K. B., Ababbo, E. D. and Tossa, B. T. (2013). The effect of dietary inclusion of *Jatropha curcas* kernel meal on growth performance, feed utilization efficiency and survival rate of juvenile tilapia. *Journal of Aquaculture Research and Development*, 4:193-197.

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Survival Rate and Condition Factor of *Clarias Gariepinus* Juveniles Fed *Pueraria Phaseoloides* Leaf Meal Inclusion Diets

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Abstract

A 10-week feeding experiment was conducted to evaluate the survival rate and condition factor of the inclusion of *Pueraria phaseoloides* leaf meal (PLM) as a protein ingredient in the diets of *Clarias gariepinus* juveniles. Five isonitrogenous diets (D1-D5) were formulated to contain 40% crude protein with inclusion of PLM at 0%, 5%, 10%, 15% and 20% levels, respectively. D1 (0% PLM) served as the control diet. One hundred and fifty *C. gariepinus* juveniles of initial mean weight of 79.87 ± 5.85 g were randomly allocated to five dietary groups (G1-G5) and three replicates each and fed with the five PLM formulated diets, respectively, at 5% biomass daily. Fifteen concrete tanks of volume 1m³ each were used for the experiment. Each tank was stocked with ten juveniles. Results showed no significant differences ($p > 0.05$) in the mean survival rate and condition factor of the experimental fish at the end of the experimental period. The present findings showed that PLM can be included in *C. gariepinus* diets up to 20% level without compromising the survival and well-being of the catfish.

Keywords: Aquaculture, feed, growth, protein, survival.

Introduction

Global demand for fish is growing due to population growth, urbanization and income growth. Sadly, increase in yields of the ocean fisheries would cause destruction of the wild fish stocks (Godwin *et al.*, 2021). Aquaculture seems to be the only alternative means of supplying fish for consumers, to fill the growing gap between supply and demand for food fish, while maintaining wild fishery harvests at sustainable levels. However, manufactured feed is a major challenge of aquaculture because feed gulps at least 60% of the total production costs (Gabriel *et al.*, 2007). Therefore, there is urgent need to search for readily available and cheap plant protein ingredients to partially or completely replace the expensive and scarce conventional protein ingredients in fish feeds for sustainability of the aquaculture industry.

Clarias gariepinus is one of the most popular fish for culture in Nigeria (Godwin *et al.*, 2021). Due to the increasing demand for catfish in Nigeria in recent years, fish farmers have increased production leading to increased stocking and feeding rates (Akinrotimi *et al.*, 2007). *Pueraria phaseoloides* is a fast-growing plant species used in soil conservation; the leaf is used as forage for animals especially rabbits in some African counties while the seeds are used as feed for birds in some Asian countries (Ifeanacho *et al.*, 2017). *P. phaseoloides* is a twiner, climbs over other plants, and can become an invasive species due to its fast growth, wide seed distribution, and ability to fully cover other plants (Godwin *et al.*, 2021). *P. phaseoloides* is found everywhere and the leaves can easily be prepared as a leaf meal. The present study seeks to evaluate the survival rate and condition factor of the inclusion of *P. phaseoloides* leaf meal in *C. gariepinus* feed for sustainability of the aquaculture industry.

Materials and Methods

Collection and Preparation of *P. phaseoloides* Leaf Meal

The *P. phaseoloides* leaf sample was sourced and collected from the premises of African Regional Aquaculture Centre (ARAC), Aluu, Rivers State, Nigeria. The leaves were shade-dried at room temperature for three weeks and ground into very fine particles. The ground sample was stored for later usage.

Formulation and Preparation of Experimental Diets

The feed ingredients used in this study include: PLM, wheat bran, soybean meal, fish meal, palm oil, garri (binder), bone meal, iodized salt, fish premix, lysine, methionine, and vitamin C. All the feed ingredients measured out summed up to 100% as shown in Table 1. Five isonitrogenous diets of 40% crude protein were formulated using

Pearson Square method. The control diet (Diet 1) contained 0% PLM, Diet 2 contained 5% PLM, Diet 3 contained 10% PLM, Diet 4 contained 15% PLM, and Diet 5 contained 20% PLM. The dough of each practical diet was pelletized separately using Atlas Diesel Engine Pelletizer (R175A, China) through a 4mm die (the appropriate feed size for the juveniles to actively eat) to produce pellets and sun-dried separately for 72 hours and more. The dry pellets were stored in air-tight plastic buckets and labeled accordingly.

Table 1: Percentage Composition of Experimental Diets

Ingredients	Diet 1 (0% PLM)	Diet 2 (5% PLM)	Diet 3 (10% PLM)	Diet 4 (15% PLM)	Diet 5 (20% PLM)
PLM	0.00	5.00	10.00	15.00	20.00
Wheat Bran	19.76	15.02	10.27	5.54	0.79
Soybean Meal	33.80	33.67	33.54	33.41	33.28
Fish Meal	33.80	33.67	33.54	33.41	33.28
Palm Oil	5.00	5.00	5.00	5.00	5.00
Garri (Binder)	5.00	5.00	5.00	5.00	5.00
Bone Meal	1.50	1.50	1.50	1.50	1.50
Salt	0.50	0.50	0.50	0.50	0.50
Premix	0.25	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15	0.15
Methionine	0.15	0.15	0.15	0.15	0.15
Vitamin C	0.10	0.10	0.10	0.10	0.10
Total (%)	100	100	100	100	100

Key: PLM – *Pueraria phaseoloides* leaf meal

Project Location

The feeding experiment was done at the African Regional Aquaculture Centre (ARAC), a Department of the Nigerian Institute for Oceanography and Marine Research (NIOMR), Aluu, Rivers State, Nigeria.

Water Quality Analysis

The water quality parameters measured include: temperature, pH, dissolved oxygen, ammonia, nitrite, and total hardness. Temperature was measured with a mercury-in-glass thermometer, while other parameters were determined using LaMotte Fresh Water Aquaculture Test Kit (Code 3633-05, USA).

Source of Experimental Fish/Acclimatization

One hundred and fifty *C. gariepinus* juveniles of the same stock and mean weight 79.87 ± 5.85 g were obtained from ARAC Catfish Hatchery. The fishes were acclimatized for two weeks and fed twice daily with ARAC catfish feed at 5% biomass.

Experimental Design, Rearing Units, and Stocking of Fish

Completely Randomized Design was used, with five treatment levels and three replicates each. A total of 15 concrete tanks of volume 1m³ each were used for the experiment. Each tank was stocked with 10 juveniles. A total of 150 juveniles were stocked.

Feeding of Experimental Fish

The experimental fish were handfed twice daily, morning and evening at 9:00 am and 4:00 pm. The daily ratio of 5% biomass was divided into two, and a half fed to the fish each time. The weight of feed fed was adjusted every two weeks to contain weight gain by fish. The experiment lasted for 10 weeks.

Survival Rate (SR)

Survival rate was calculated from the formulae:

$$SR = \frac{\text{Number of fish alive}}{\text{Number of fish stocked}} \times 100$$

Condition Factor (K)

Condition factor was calculated from the formulae:

$$K = \frac{100W}{l^3}$$

W is the average weight of fish.

l is the average standard length of fish.

Data Analysis

Data obtained from the study were subjected to Analysis of Variance (ANOVA) using SPSS (version 21) and comparisons were done at 0.05 significance level. Values were expressed as mean $\pm$ standard deviation (mean $\pm$ S.D) of triplicate determinations.

Results

Table 2: Proximate Composition of *P. phaseoloides* Leaf Sample

Nutrients	% Composition
Moisture	5.23 $\pm$ 0.23
Ash	5.35 $\pm$ 0.75
Crude Protein	18.31 $\pm$ 2.62
Crude Fat	7.00 $\pm$ 0.00
Crude Fibre	43.96 $\pm$ 4.09
Carbohydrate	20.15 $\pm$ 0.57

Values are mean $\pm$ standard deviation of triplicate determinations.

Table 3: Water Quality Parameters

Parameters	Experimental Tanks				
	Tank 1 (control)	Tank 2	Tank 3	Tank 4	Tank 5
pH	6.68 $\pm$ 0.02 ^a	6.66 $\pm$ 0.01 ^a	6.61 $\pm$ 0.08 ^a	6.62 $\pm$ 0.03 ^a	6.62 $\pm$ 0.02 ^a
Temperature (°C)	27.27 $\pm$ 0.01 ^b	27.28 $\pm$ 0.01 _b	27.28 $\pm$ 0.02 ^b	27.29 $\pm$ 0.01 _b	27.29 $\pm$ 0.01 ^b
Dissolved Oxygen (mg/l)	6.62 $\pm$ 0.01 ^c	6.59 $\pm$ 0.02 ^c	6.60 $\pm$ 0.02 ^c	6.59 $\pm$ 0.02 ^c	6.60 $\pm$ 0.02 ^c
Ammonia (mg/l)	0.10 $\pm$ 0.01 ^d	0.11 $\pm$ 0.02 ^d	0.12 $\pm$ 0.02 ^d	0.12 $\pm$ 0.02 ^d	0.12 $\pm$ 0.02 ^d
Nitrite (mg/l)	0.29 $\pm$ 0.01 ^e	0.29 $\pm$ 0.01 ^e	0.29 $\pm$ 0.01 ^e	0.30 $\pm$ 0.02 ^e	0.29 $\pm$ 0.02 ^e
Total Hardness (mg/l)	43.46 $\pm$ 0.02 ^f	43.48 $\pm$ 0.02 ^f	43.47 $\pm$ 0.02 ^f	43.47 $\pm$ 0.03 ^f	43.45 $\pm$ 0.01 ^f

Values are mean $\pm$ S.D. of triplicate determinations. Values with similar superscript letters along the same row are not significantly different (p>0.05) compared to the control (Tank 1).

Table 4: Survival Rate (SR) and Condition Factor (K) of the Experimental Fish

Parameters	Experimental Groups				
	Group 1	Group 2	Group 3	Group 4	Group 5
	(control)				
SR (%)	96.67 $\pm$ 4.71 ^a	98.00 $\pm$ 2.98 ^a	98.67 $\pm$ 1.82 ^a	100.00 $\pm$ 0.0 ^a	100.00 $\pm$ 0.00 ^a
K (g/cm ³)	1.07 $\pm$ 0.14 ^a	1.15 $\pm$ 0.10 ^a	1.09 $\pm$ 0.13 ^a	1.02 $\pm$ 0.03 ^a	1.01 $\pm$ 0.02 ^a

Values are mean $\pm$ S.D. of triplicate determinations. Values with similar superscript letters along the same row are not significantly different ($p > 0.05$) compared to the control (Group 1).

Discussion

Phytochemicals Screening of *P. phaseoloides* Leaf Sample

Phytochemicals are widely known to have protective effects against chemically-induced oxidative damage, by enhancing the antioxidant defence system of animal tissues and blocking oxidative stress (Abarikwuet *al.*, 2018). In the present study, we observed cardiac glycosides, flavonoids, saponins, and quinones as phytochemicals present in the *P. phaseoloides* leaf sample. These phytochemicals improved the quality of the PLM inclusion diets and thus enhanced the survival of the experimental fish.

Water Quality Parameters

Fishes go about their activities inside water and are dependent on water for feeding, respiration, excretion, osmoregulation, growth, and reproduction. Thus, a successful aquaculture business is dependent on the health of the fish and good water quality management. In the present study, the water quality parameters recorded no significant differences ($p > 0.05$) in all the experimental tanks and were within acceptable tolerant ranges recommended for freshwater fish culture (Ariweriokuma *et al.*, 2017). Hence, the basic water quality parameters measured did not affect any observed differences in the performance of the experimental fish.

Survival Rate (SR) and Condition Factor (K) of the Experimental Fish

In the present study, the mean values of SR and K showed no significant differences ($p > 0.05$) across all the dietary groups at the end of the 10-week feeding experiment. This implied that the levels of inclusion of PLM in the formulated diets did not compromise survival and fitness of the experimental fish. Furthermore, the good survival rates (96.67 – 100%) of *C. gariepinus* juveniles across all the dietary groups in this study were achieved due to the maintenance of good water quality. The fish also displayed good adaptability to the formulated feeds in the culture media. The handling techniques of the fish were also good. The hardy nature of the fish as reported by Nwadukwe and Ayinla (2004) also contributed to the fish survival.

Conclusion

P. phaseoloides is an invasive weed; readily available all-year-round in the tropics, and has no competition for human consumption. In the present study, increased inclusion of PLM in the formulated diets up to 20% level did not compromise the survival and well-being of the experimental fish at the end of the 10-week feeding period. It can then be concluded that PLM can be included in the diets of *C. gariepinus* up to 20% level, for sustainability of the aquaculture industry.

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References

- Abarikwu, S. O., Godwin, S. O. & Onuoha, S. C. (2018). Morphometric Evaluation of the Seminiferous Tubules and the Antioxidant Protective Effects of Gallic Acid and Quercetin in the Testis and Liver of Butyl Phthalate Treated Rats. *Indian Journal of Clinical Biochemistry*, 35, 20-31.
- Akinrotimi, O. A., Gabriel, U. U., Owihonda, N. K., Onunkwo, D. N., Opara, J. Y. & Cliffe, P. T. (2007). Formulating an environmentally friendly fish feed for sustainable aquaculture development in Nigeria. *Agricultural Journal*, 2(5), 606-612.
- Ariweriokuma, S. V., Gabriel, U. U., Ansa, E. J. & Akinrotimi, O. A. (2017). Growth response of African catfish (*Clarias gariepinus*) fed dietary inclusion levels of green leaf (*Amaranthus cruentus*). *International Journal of Innovative Studies in Aquatic Biology and Fisheries (IJISABF)*, 2(2), 23-38.
- Gabriel, U. U., Akinrotimi, O. A., Bekibele, D. O., Onunkwo, D. N. & Anyanwu, P. E. (2007). Locally produced fish feed: potentials for aquaculture development in sub-Saharan Africa. *African Journal of Agricultural Research*, 2(7), 287-295.
- Godwin, S. O., Wegwu, M. O., & Ifeanchi, M. O. (2021). Economic viability of *Pueraria phaseoloides* leaf meal inclusion diets fed to *Clarias gariepinus* juveniles. *Nigerian Journal of Fisheries*, 18(1), 2148-2153.

- Ifeanacho, M. O., Abbey, B. W. & Ayalogu, E. O. (2017). Variation in Body Weight, Organ Weight and Haematological Parameters of Rats Fed with Diets Based on Treated African kudzu (*Pueraria phaseoloides*, roxb. Benth) Seeds. *Journal of Applied Sciences Environmental Management*, 21 (6), 1013-1018.
- Nwadukwe, F. O. & Ayinla, A. O. (2004). The growth and survival of brood catfish fingerlings under three dietary treatments in concrete tanks. *African Journal of Applied Zoology and Environment*, 3(4), 16-25.

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Growth performance of *Oreochromis niloticus* fingerlings fed varying inclusion levels of Locust bean seed (*Parkia biglobosa*)

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Abstract

The study investigated the growth performance of *Oreochromis niloticus* fingerlings fed with five isonitrogenous diets containing 40% crude protein at varying inclusion levels of (FLBM) as a replacement for soybean meal was carried out for 56 days. Five diets containing 40% crude protein at varying replacement levels of soybean meal (SBM) and Fermented Locust bean meal (*Parkia biglobosa*) as designated (T1 - 0% FLBM /100% Soybean meal), T2 (25% FLBM /75% soybean meal), T3 (50% FLBM /50% soybean meal), T4 (75% FLBM/25% soybean meal), T5 (100% FLBM 0% soybean meal). The result of the experiment shows that the best weight gain of (4.12), specific growth rate, (2.07), feed conversion ratio (1.33), and survival rate (95.52) were from fish fed with T2. The results obtained indicated significant differences ($P < 0.05$) to other diets. Temperature, dissolved oxygen, pH, and ammonia were not significantly different ($p < 0.05$) in this experiment. Based on the findings of the study, it can be deduced that fermented locust bean meal can replace soybean meal up to 25% in the diet of *Oreochromis niloticus* fingerlings without any adverse effect.

Keywords: Locust bean seed, soybean meal, *O. niloticus*, diet

Introduction

The growing demand to substitute soybean meal with readily available protein sources in the practical diet of fishes cannot be over-emphasized due to the various uses to which it is applied (Gabriel *et al.*, 2007). Such a protein source being sought for must have low or no direct demand for human consumption so that they can contribute maximally towards satisfying the demand for aquaculture feed industries (Renna *et al.*, 2017). Ordinarily, plants provide nearly two-thirds of the world's supply of food protein for humans and animals of which 10-15% come from legumes (Nyakeri *et al.*, 2017). Among the legumes, soybean is valued for its high (38–45%) protein content as well as its high (approximately 20%) oil content (Renna *et al.*, 2017). The competitive demand for conventional plant protein (soybean meal) limits its availability and has led to the high cost of livestock feed in Nigeria (Ogunlande, 2007). Therefore, in an attempt to attain a more economically sustainable and viable production, research interest has been directed towards the evaluation and use of unconventional or cheaper protein sources, particularly from plant products such as seeds, leaves, and other agricultural by-products (Green and Popa, 2012). This study focuses on the substitution of soybean meal with fermented African locust bean meal (*P. biglobosa*) in formulating fish diets using *Oreochromis niloticus* fingerlings.

Materials and Methods

Experimental area: The experiment was carried out at the aquaculture unit of the Demonstration Farm, Department of Fisheries, Faculty of Agriculture, University of Port Harcourt, Choba, Rivers State. A total of 300 fingerlings of *Oreochromis niloticus* with an average weight of 1.93g were obtained from African Regional Aquaculture Centre (ARAC) Aluu Rivers State.

Seed collection and Preparation: The *P. biglobosa* seeds were sourced from Oba market, Akure, Ondo State, Nigeria, seeds were boiled for 12 hours without enzyme or starter culture in a pot to soften the seed coats. The seeds were lightly pounded with pestle and mortar to separate the seed coats from the seeds. The decorticated seeds were then being wrapped in a polyethylene bag, placed inside a basket to drain. The fermentation process lasted until the seeds turn dark brown and softened, which took about 72 hours. The fermented locust bean (*P. biglobosa*) was sun-dried for 14 days and oven-dried for 30 minutes at a temperature of 40°C for ease of grinding and pulverization with other feed ingredients. They were ground into powder form to produce fermented locust bean meal (FLBM).

Water quality parameters: The water in the experimental tanks was regularly monitored and measured weekly for the Physico-chemical properties and was renewed. The following parameters were measured in-situ using a

multipurpose pH meter for both temperature and pH, a DO meter for dissolved oxygen, and an ammonia assay kit for ammonia.

Experimental feed: Five diets containing 40% crude protein at varying replacement level of soybean meal (SBM) and Fermented Locust bean meal (*Parkia biglobosa*) as designated (T1 - 0% FLBM /100% soybean meal), T2 (25% FLBM /75% soybean meal), T3 (50% FLBM /50% soybean meal), T4 (75% FLBM/25% soybean meal), T5 (100% FLBM 0% soybean meal).

Growth parameters: The total weight gain (TWG), relative growth rate (RGR) (%), specific growth rate (SGR) (%/day), total feed intake (TFI), feed conversion ratio (FCR), protein efficiency ratio (PER) and survival (%) were determined according to the method of Jamabo *et al.*, 2016. All parameters were measured for all the treatments and their replicates. Mortalities were recorded as they occurred.

Statistical Analysis: Data obtained was subjected to one-way analysis of variance (ANOVA). Differences between means were separated using Least Significant Difference (LSD) at a probability level of $P < 0.05$.

Results

The summary of Physico-chemical parameters of experimental waters during the period of study is shown in table 1. The results obtained indicated no significant differences between the means of the different levels of treatment ($P < 0.05$). The result on growth performance of the experiment shows that the best weight gain of (4.12g), specific growth rate, (2.07), feed conversion ratio (1.33), and survival rate (95.52) were from fish fed with 25% locus bean seed (T2).

Table 1: Physico-chemical parameter of experimental water

Parameter	T1 (0% FLBS)	T2 (25% FLBS)	T3 (50% FLBS)	T4 (75% FLBS)	T5 (100% FLBS)
Temperature	27.77 ± 0.11 ^a	27.24 ± 0.08 ^a	27.52 ± 0.08 ^a	27.30 ± 0.08 ^a	28.41 ± 0.05 ^a
pH	6.78 ± 0.00 ^a	6.84 ± 0.02 ^a	6.95 ± 0.04 ^a	6.96 ± 0.00 ^a	6.99 ± 0.02 ^a
Ammonia	0.18 ± 0.02 ^a	0.23 ± 0.02 ^a	0.24 ± 0.01 ^a	0.25 ± 0.01 ^a	0.28 ± 0.4 ^a
Dissolved oxygen	7.68 ± 0.17 ^a	7.52 ± 0.02 ^a	7.38 ± 0.19 ^a	7.33 ± 0.19 ^a	7.23 ± 0.10 ^a

Values are Mean±SE with the same superscript values are not significantly different at $p > 0.05$.

Table 2. Growth performance of *O. niloticus* fed diets with different inclusion levels of Locust bean seed

Parameter	T1 (0%FLBS)	T2 (25%F LBS)	T3 (50% FLBS)	T4 (75% FLBS)	T5 (100% FLBS)
Initial weight	2.40 ± 0.022 ^a	1.93±0.012 ^a	2.12±0.030 ^a	2.09±0.012 ^a	2.01±0.032 ^a
Final weight	4.71±0.021 ^b	6.21±0.003 ^a	5.32±0.001 ^b	4.21±0.003 ^c	5.00±0.005 ^b
Mean weight gain	2.33±0.321 ^b	4.12±0.102 ^a	2.3±0.005 ^b	1.32±0.001 ^c	3.21±0.023 ^b
Feed conversion ratio	1.92±0.005 ^a	1.33±0.001 ^c	2.12±0.012 ^a	2.7±0.023 ^b	3.2±0.012 ^b
Specific growth rate	1.29±0.012 ^a	2.07±0.001 ^b	1.33±0.003 ^a	1.42±0.05 ^a	1.37±0.003 ^a
Survival rate	67.23±3.37 ^a	95.52±0.07 ^b	76.01±5.40 ^b	57.34±2.12 ^a	45.03±2.10 ^b
Feed intake	2.96±0.003 ^a	1.21±0.001 ^a	1.34±0.001 ^b	2.01±0.011 ^a	1.85±1.002 ^a

Discussion

The physico-chemical parameters of water were within the acceptable range recommended for rearing and culture of most tropical fish, including the Nile tilapia (Fafioye *et al.*, 2005; Duniya, 2006). The use of *Parkia biglobosa* in the diet of *Oreochromis niloticus* at 25% partial inclusion level showed significant improvement on the growth performance and nutrient utilization of the fish. This may be as a result of high nutritional content of the *P. biglobosa* seed. Adikwu (2003), documented that the lower the value of the FCR, the better the feed utilization by the fish. In this present study, the lowest value of FCR indicated better feed utilization by the fish and this accounted for better growth performance of *O. niloticus* fed at 25% inclusion level among other diets. This result supports the observation made by Hassanin *et al.*, (2014) and Siegrist, (2008) in related studies. Fish mortality recorded in the treatment might be attributed to the presence of some extraneous factors in the diets which is in agreement with that of Gomiero *et al.*, (2005), who reported that mortality might not be attributed to the presence of anti-nutrients in the diets alone but also to some extraneous factors such as stress resulting from handling.

Conclusion

The results from this study showed that fermented African locust beans meal could be used at recommended level of inclusion to promote growth of *Oreochromis niloticus* and also, serve as a good plant protein supplement that can be used to replace soybean meal. From the experiment, 25% inclusion of LBSM in the diet of *Oreochromis niloticus* was highly utilized for growth. This indicates that LBSM if thermo-treated for anti-nutrition factors such as tannin could replace soya bean up to 25% in the diet of fish feed composition. This level would be significantly replacing expensive soya bean in the fish feed manufacturing industries since locust bean is an agricultural product with no direct competition with man.

References

- Duniya, J.N. (2006). Effect of processed locust bean seeds (*Parkia biglobosa*) substituted diet on the growth of mud catfish (*Clarias gariepinus* Burchell) Unpublished MSc, thesis, Department of Biological Science, Faculty of Science, Ahmadu Bello University, Nigeria, 64pp.
- Fafioye, O.O., Fadage, S.O., Adebisi, A. A., Jenyo –oni and Omoyinmi, G.K.A., (2005). Effect of dietary soybean on growth performance and body composition of African Catfish (*Clarias gariepinus*, Burchell) fingerlings. *Turkish journal of fisheries and Aquatic Sciences* 5:11-15,
- Gabriel, U.U., Akinrotimi, O.A., Bekibele, D.O., Onunkwo, D.N., and Anyanwu, P.E. (2007) Locally produced fish feed: potentials for aquaculture development in sub-Saharan Africa. *African Journal of Agricultural Research* 2, 287–295.
- Gomiero, L. M. and F. M. S Braga (2005). The Condition Factor of Fishes from Two River Basins in Sao Paulo State, Southeast of Brazil. *Acta Scientiarum*, 27:73-78

- Green, T. R., and Popa, R. (2012). Enhanced ammonia content in compost leachate processed by black soldier fly larvae. *Applied biochemistry and biotechnology*, 166(6), 1381–1387.
- Hassanin, M. E., Hakim, Y. and M. E. Badawi (2014). Dietary effect of ginger (*Zingiber officinale* Roscoe) on growth performance, immune response of Nile Tilapia (*Oreochromis niloticus*) and disease resistance against *Aeromonas hydrophila*. *Abbassa International Journal for Aquaculture.*, 7 (1): 35-52.
- Jamabo, N.A. Yor-Oh, M. M. and Dienye, H. E. 2016. Effect of water energizer on the growth and survival of *Clarias gariepinus* (Burchell, 1822) FRY. *Journal of Agriculture and Veterinary Science (IOSR-JAVS)* 9 (11): 72-74.
- Nyakeri, E.M.; Ogola, H.J.; Ayieko, M.A. and Amimo, F.A. (2017). An open system for farming black soldier fly larvae as a source of proteins for small scale poultry and fish Production. *Journal of Insects as Food and Feed* 3: 51–56.
- Ogunlande I. (2007) Backyard fish farmers information needs in Osun State, Nigeria. *AAAE conference proceeding University of Ilorin, Nigeria* 165 – 169.
- Renna, M.; Schiavone, A.; Gai, F.; Dabbou, S.; Lussiana, C.; Malfatto, V.; Prearo, M.; Capucchio, M.T.; Biasato, I.; and Biasibetti, E. (2017). Evaluation of the suitability of a partially defatted black soldier fly (*Hermetia illucens* L.) larvae meal as ingredient for rainbow trout (*Oncorhynchus mykiss walbaum*) diets. *Journal of Animal Science and Biotechnology* 8, 57.
- Siegrist, M. (2008). Factors influencing public acceptance of innovative food technologies and products. 19: 603–608.

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Effect of *Moringa oleifera* full-fat seed meal as a replacement for fish meal on the growth performance and hematological indices of *Clarias gariepinus* fingerlings

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Abstract

Searching for alternative to fish meal led to a 56-day trial on the growth performance and hematological parameters of *Clarias gariepinus* fingerlings fed with *Moringa oleifera* full-fatseed meal (MSM). Two hundred and twenty five(225) fingerlings of *Clarias gariepinus* (12.63 ±0.22g) were stocked in 15 plastic tanks (60 cm x 45 cm x 30 cm of 25 liters capacity). Fifteen (15) fingerlings were stocked in a completely randomized design in triplicate and fed twice daily at 5% body weight. Five diets were formulated at 40% crude protein containing 0% (T1), 25% (T2), 50% (T3), and 75% (T4) and 100% (T5) moringa seed meal. The results of growth performance and haematological indices showed significant difference ($p<0.05$) across the treatments. Diet 1 (0% moringa) had significantly ($p<0.05$) high mean weight gain and feed conversion ratio (45.40 g; 1.64) while diet 5 recorded the least (-0.10g;17.57) respectively. Diet 1 had the least packed cell volume value (22.97 %) and the highest was observed for diet 5 (24.97 %). Hemoglobin was least for diet 5 (3.17 g/dl) and highest for diet 4 (8.07g/dl) while red blood cell was highest in diet 5 (3.17 million/mm³) and lowest in diet 2 (2.67 million/mm³). Diet 5 indicated highest white blood cell count (31.97 x 10⁹/mm³) and least value in fish fed diet 2 (26.97 x 10⁹/mm³). The result of the research revealed that *Moringa oleifera* full fat seed meal can substitute fishmeal in *Clarias gariepinus* diet at a maximum inclusion level of 25% beyond which there was a decline in growth performance and blood indices which could indicate possible health hazard to the fish.

Introduction

With increased demand and the health benefits of eating fish (FAO 2000; FAO 2006), the tremendous expansion in fish farming activity is confronted with challenge of supplying adequate and quality feed for the utmost growth of fish. Studies are conducted to lessen the dependence on fishmeal, due to its scarcity and high cost (Tacon *et al.*, 2006; Rana *et al.*, 2009).The search for unconventional protein sources, largely from plant by-products like leaves, seeds, and other agricultural feedstuff that are economically secure, environmentally friendly and profitable production is imperative (Richter *et al.*, 2003; Abo-State *et al.*, 2014).*Moringa oleifera* seed is one of such locally available fish feed ingredients for exploitation.

Moringa species of family Moringaceae is *Moringa oleifera* (Paliwal *et al.*, 2011) also referred to as drumstick tree, horseradish tree, ben oil or benzoil tree (Olson *et al.*, 2010). Francis *et al.* (1999) documented *Moringa oleifera* as a widely dispersed species in Africa and Asia. It is a protein source for aquaculture diets (Chiseva, 2006).*Moringa oleifera* is mostly grown in tropical and subtropical countriesandit requires a sandy or loamy soil with a pH of slightly acidic to slightly alkaline, and 250–3000 mm of net rainfall (Thurber and fahey 2010). *M. oleifera* provides a plethora of essential nutrients and anti-nutrients in all parts of the plant. Minerals like calcium, potassium, zinc, magnesium, iron, and copper are abundant in the leaves of *M. oleifera* (Kasolo *et al.*, 2010).It also contains vitamins such as beta-carotene, folic acid, pyridoxine and nicotinic acid, vitamin C, D and E (Mbikay, 2012). The seeds have been studied extensively as an oil source. Moringa seed protein content is higher than that of legumes and soybean cultivars (Ferreira, 2008). *Moringa seed cake may be a greater source of digestible protein than moringa leaves, according to in vitro testing using the gas generation method* (Kakengi *et al.*, 2005).*Clarias gariepinus* is important in African aquaculture due to its fast development rate and resilience (Fagbenro *et al.*, 1999). This study focused on the effect of Moringa full fat seed meal as a fishmeal substitute on *Clarias gariepinus* growth and haematological performance.

Materials and Methods

The ingredients used were moringa seeds, vitamin premix, fish meal, maize meal, palm oil, baobab pulp weighed using electronic sensitive weighing balance(SF-400; Capacity 3000_gx1_g/106_{oz}x0.1_{oz}).

Experimental Site

This research took place at the laboratory of the Department of Water Resources, Aquaculture and Fisheries Technology, School of Agriculture and Agricultural Technology, Federal University of Technology Minna, Niger State (latitude 9°53'27.4"N longitude 6°45'20.6"E).

Experimental Fish and setup

Two hundred and twenty-five fingerlings *Clarias gariepinus* (12.63 ± 0.22g) were purchased from Talba farm Minna, Niger State. The fish were acclimatized for one week and fed with (name of brand of the diet, cp and size) commercial diet. The fish were weighed at the commencement of the feeding trial and randomly stocked in a completely randomized design in fifteen plastic tanks at 15 fish per tank of (60 cm x 45 cm x 30 cm) dimension and 25 liters capacity comprising five (5) treatments replicated thrice (3).

Plant Seeds Collection and Preparation

The seeds of the moringa were sourced from the kure ultra-modern market, Minna, Niger State. It was dehusked and safely preserved in a deep freezer at (-4°C) until used.

Proximate Analysis of Feed stuff

The feedstuffs and diets were analyzed for crude protein, lipid, ash, fibre and moisture according to the method of AOAC(2000) Table 1.

Table 1: Proximate analyses of feedstuffs

Feedstuffs	Crude Protein %	Moisture %	Lipids %	Ash %	Crude Fibre %	NFE %
Fish meal	56.87	0.77	13.64	7.75	0.30	20.67
Moringa Seed Meal	39.02	2.30	34.25	4.19	3.60	17.08
Maize	10.50	4.46	18.62	2.86	1.30	62.26

Hematological analysis

Blood samples were analysed for packed cell volume (PCV), red blood cells (RBC), white blood cells (WBC), and hemoglobin (Hb) according to the procedures of Roberts (1978), Mgbenka *et al.* (2003), and Shah and Altindag (2004), as updated by (Bamidele *et al.*, 2015)

Phytochemical analysis

The phytochemical analyses for saponin, phenols were conducted according to the methods of Keay *et al.* (1964) The alkaloid and tannin were determined according to Harborne (1973).

Feed formulation

Five experimental diets were compounded at 40% crude protein using Pearson's square method. The control (diet 1) contained 100% fish meal while diets 2-5 contained moringa seed meal at 25%, 50%, 75% and 100% in replacements for fish meal (Table 2).

Proximate Analysis of Experimental Diets

The formulated diets were analyzed and the results is shown in Table 2.

Table 2: Composition of experimental diets

Feed stuffs	Diet 1(Control)	Diet 2(25%)	Diet 3 (50%)	Diet 4 (75%)	Diet 5 (100%)
Moringa	0.00	250.00	500.00	750.00	809.00
Fish Meal	706.80	373.50	145.50	22.60	0.00
Maize	243.20	326.00	304.50	177.40	140.30
Vitamin premix	20.00	20.00	20.00	20.00	20.00
Palm oil	30.00	30.00	30.00	30.00	30.00
Total	1000	1000	1000	1000	1000
Proximate analysis (%)					
Crude protein	39.37	40.25	39.62	39.37	40.19
Crude lipid	26.10	23.80	25.30	34.40	30.10
Crude fibre	6.10	3.30	0.70	1.40	2.50
Ash	15.35	15.58	8.15	7.80	6.15
Moisture	6.18	6.20	6.81	6.50	6.38

Experimental Procedure

The *Clarias gariepinus* fingerlings were fed with the experimental diets twice per day, by 9:00am and 5:00pm at 5% body weight and adjusted accordingly. The fish were weighed at 2 weeks interval using the sensitive weighing scale (SF-400; Capacity 3000_g x 1_g/106_{oz} x 0.1_{oz}). Water exchange was done daily and water quality parameters measurements were conducted weekly for temperature, total alkalinity, pH and dissolved oxygen (APHA, 1992). Uneaten diets were siphoned daily, oven dried and kept for later analysis. The experiment was conducted for a period of eight weeks (56 days).

Growth Parameters Evaluation

According to Maynard *et al.* (1979); Bondi (1987) and Halver (1989) the following biological parameters were measured;

$$\text{Mean weight gain} = \frac{W_{\text{Final}} - W_{\text{Initial}}}{\text{No of fish}}$$

$$\text{Specific growth rate (\%/Day)} = \left[\frac{(\ln W_2 - \ln W_1)}{\text{Number of days}} \times 100 \right] \text{ (Brown, 1957)}$$

$$\text{Food conversion ratio} = \frac{\text{Feed fed (g)}}{\text{Live weight gain (g)}}$$

$$\text{Apparent net protein utilization ANPU (\%)} = \frac{(P_2 - P_1)}{\text{Total protein consumed (g)}} \times 100 \text{ Miller and Bender (1955); Where, } P_1 = \text{initial carcass protein (g) and } P_2 = \text{final carcass protein (g).}$$

Data analysis

The Minitab 19.1 statistical tool was used to for significance of data obtained at 5% probability level.

Results

Growth Performance and Nutrient Utilization

Table indicated the result of phytochemical content of moringa seed meal. The saponing and alkaloid were 7.25% and 5.6% respectively while tannin and phenols were 0.48% and 0.14%. Treatment 1 recorded a significantly ($p < 0.05$) highest weight gain (45.40g) (and least feed conversion rate (1.64) compared to other treatments. Significantly ($p < 0.05$) lowest weight gains of 0.04 and 0.10g were observed in fish fed diets 4 and 5 respectively while fish fed diet 5 recorded highest feed conversion ratio of 17.9. Fish fed diets 1 and 2 had significantly ($p < 0.05$) highest SGR values of 2.34 and 1.65% respectively. Treatment 1 had the best apparent net protein utilization (ANPU) of 45.28% and is significantly different ($p < 0.05$) from other treatments.

Table 3: *Moringa oleifera* seed phytochemical analysis results

	Tanninsmg/100g	Phenolsmg/100g	Saponinsmg/100g	Alkaloidsmg/100g
Moringa seed	0.48	0.14	7.25	5.62

Table 4: Table of Growth Parameters of *C. gariepinus* fed moringa seed meal for 56 days

Growth Parameters	T1 (control)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)
Mean initial weight (g)	12.55±0.09 ^a	12.44±0.18 ^a	12.63±0.23 ^a	12.74±0.32 ^a	12.81±0.23 ^a
Mean final weight (g)	57.96±0.81 ^a	31.43±3.99 ^b	21.17±1.97 ^c	12.78±2.18 ^d	12.71±0.49 ^d
Mean weight gain (g)	45.40±0.896 ^a	18.99±4.17 ^b	8.54±2.14 ^c	0.04±1.86 ^d	0.10±0.70 ^d
Mean feed consumed (g)	74.61±3.92 ^a	41.54±9.53 ^b	24.76±10.02 ^{bc}	3.82±1.46 ^d	7.53±1.96 ^{cd}
Feed conversion rate	1.64±0.12 ^c	2.19±0.22 ^b	2.84±0.62 ^b	3.47±4.92 ^d	17.9±22.1 ^a
Specific growth rate (%/day)	2.34±0.72 ^a	1.65±0.27 ^{ab}	0.92±0.20 ^{bc}	0.01±0.25 ^c	0.01±0.10 ^c
Apparent net protein utilization (%)	45.28±0.61 ^a	2.84±3.14 ^d	8.20±0.80 ^c	17.57±0.51 ^b	9.51±1.34 ^c
Protein efficiency ratio	0.02±0.00 ^a	0.01±0.00 ^a	0.01±0.00 ^a	0.004±0.02 ^a	-0.01±0.00 ^a
Survival (%)	95.56	88.89	93.33	77.78	84.44

Means on the same row with different superscripts are significantly different ($p < 0.5$)

Haematology

The hematology indices in Table 5 shows significant difference ($p < 0.05$) among the packed cell volume (PCV) of all the treatments ($p < 0.05$) while the hemoglobin concentration between Treatments 1 (7.83), 4 (8.08) and 5 (3.17) were significantly different ($p < 0.05$). The red blood cells count (RBC) among treatments 1, 3 and 4 were not significant ($p > 0.05$) while treatments 2 and 3 revealed significant difference ($p < 0.05$) while only treatment 3 recorded a significantly ($p < 0.05$) lowest value compared to other treatments.

Table 5: Haematology of *Clarias gariepinus* fed *Moringa oleifera* based diets

Parameters	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)
Packed Cell Volume(PCV) (%)	22.97±0.06 ^c	20.97±0.06 ^e	21.97±0.06 ^d	23.97±0.06 ^b	24.97±0.06 ^a
Haemoglobin (Hb; g/dl)	7.83±0.06 ^c	7.43±0.06 ^d	7.47±0.06 ^d	8.07±0.06 ^b	3.17±0.06 ^a
Red blood cells (RBC) (million/mm ³)	2.97±0.06 ^b	2.67±0.06 ^c	2.90±0.01 ^b	2.97±0.06 ^b	3.17±0.06 ^a
White Blood Cells (No/mm ³)	31.27±0.58 ^{ab}	26.97±0.06 ^c	30.77±0.06 ^b	31.87±0.06 ^a	31.97±0.06 ^a

Means on the same row with different superscripts are significantly different ($p < 0.05$)

Table 6: Liver function test of *Clarias gariepinus* fed moringa seed meal

Parameters	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)
Bilirubin (conjugate)	0.63±0.01 ^a	0.67±0.01 ^d	1.06±0.01 ^b	1.60±0.01 ^b	3.84±0.01 ^a
Bilirubin (Total)	0.86±0.01 ^d	0.93±0.01 ^{cd}	0.97±0.01 ^c	1.30±0.01 ^b	4.62±0.01 ^a
SGOT	38.67±0.58 ^a	46.67±0.85 ^d	53.67±0.85 ^c	57.00±1.00 ^b	66.67±0.85 ^a
SGPT	29.67±0.58 ^d	32.67±0.58 ^c	30.67±0.58 ^d	36.67±0.58 ^b	48.67±0.58 ^a
Alkaline Phosphate	9.67±0.58 ^a	12.17±0.06 ^d	18.17±0.06 ^b	19.67±0.6 ^b	28.57±0.06 ^a
Total Protein	4.30±0.006	4.38±0.006 ^d	4.90±0.006 ^c	5.18±0.006 ^b	6.80±0.006 ^a

Means on the same row with different superscripts are significantly different ($p < 0.05$)

Key: SGOT- Serum glutamic-Oxaloacetic transaminase; SGPT- Serum glutamic pyruvic transaminase

Water Quality Parameters

The temperature range between 24.87 °C to 25.32 °C for the treatments ($p>0.05$). The pH ranges between (6.49-6.62) values ($p>0.05$). Dissolved oxygen (2.37 to 3.27 ($p>0.05$)) and total alkalinity levels ranged significantly ($p<0.05$) across the treatments (196-237.70).

Discussion

The use of moringa full fat seed meal in *Clarias gariepinus* fingerlings diet as replacement for fish meal was demonstrated in this study. The results indicated crude protein value of 39.02 % higher than 35.21% reported by Bamidele *et al.* (2015). The fish consumed more of the control diet (100% fish meal) followed by 25% moringa seed meal while lower consumption rate was recorded for other diets with increasing inclusion of moringa seed meal. Richter *et al.* (2003) reported substantial loss in weight gain when *M. oleifera* leaf meal was substituted for fish meal due to the presence of anti-nutrients such as tannins, saponins, alkaloids, and phenols as observed in this study. The low feed intake with increased inclusion of moringa seed meal and the consequent decline in growth can be attributed to the high presence of the anti-nutritive factors; saponin (7.25mg/100g) and alkaloids (5.62mg/100g) in the diets in agreement with Soetan and Oyewole (2009) who stated that saponins confer a bitter taste in dietary plants which is the primary limiting factor in their use. Diets 4 and 5 recorded highest mortality rates (77.78%) and (84.44%) respectively, which could be attributed to the negative effects of the anti-nutritional factors at higher inclusion levels. The anti-nutrients obtained in this research is low in tannins (0.48mg/100g) and phenols (0.14mg/100g), and higher in saponins (7.25mg/100g) and alkaloids (5.62mg/100g) than those reported by Bamidele *et al.* (2015) tannins (2.36mg/100g), phenols (2.06mg/100g), saponins (0.12mg/100g) and alkaloids (0.64mg/100g) the variation could be due to environmental effects on the plant.

Hematological parameters evaluated indicated high stress level as inclusion level increases in line with Adesina (2017) who said that blood analysis is a valuable way to evaluate the physiological condition of cultured fish while determining the impacts on fish health and other stress factors. The white blood cells were high with decreased hemoglobin count at higher inclusion levels of moringa full fat seed meal, and this signifies stress and anaemia in the experimental fish as reported by Akintayo *et al.* (2008) and Yue and Zhou (2008). The bilirubin, a marker of metabolic waste production from the breakdown of red blood cells shows variation across all treatments, suggesting that there is a higher risk of liver failure with increasing bilirubin levels at higher inclusion levels of *Moringa oleifera* full fat seed meal in the diet of fish.

Conclusion and recommendation

Moringa seed meal can substitute for fish meal at 25% inclusion level in the diets of *C. gariepinus* without any deleterious effect on growth performance as well as the health status of the fish. Processing of moringa seed meal is thus recommended to lower or eliminate the anti-nutritional factors to enhance nutrients utilization.

References

- Abo-State, H., Hammouda, Y., El-Nadi, A. and Abo- Zaid, H. (2014). Evaluation of Feeding raw Moringa (*Moringa oleifera* Lam.) leaves meal in Nile tilapia fingerlings (*Oreochromis niloticus*) diets. *Global Vet.*, 13: 105-111.
- AOAC, (2000). Official Methods of Analysis, Association of Official Analytical Chemists, Washington, DC, USA, 18th edition, 2000
- APHA, (1992). Standard method for examination of water and waste water *American public health*. Washington, DC.
- Adesina, S.A. (2017). Haematological and Serum Biochemical Profiles of *Clarias gariepinus* Juveniles Fed Diets Containing Different Inclusion Levels of Mechanically Extracted Sunflower (*Helianthus annuus*) Seed Meal. *Applied Tropical Agriculture*, Volume 22, No. 2, 24-35, .
- Akintayo, I.A., Obasa S.O., Alegbeleyo, W.O. and Bangbose, A.N. (2008). Evaluation of toasted sunflower (*Helianthus annuus*) seed meal in the diets of African catfish (*Clarias gariepinus*) fingerling. *Livestock Research for Rural Development*, 20(10) 28-46.
- Bondi, A.A. (1987). Animal Nutrition. John Wiley and Sons, New York. 504pp
- Brown, M.E. (1957). Experimental Studies on growth. In: Hoar, W.S. and D.J. Randell (Eds.) *Physiology of Fishes*. Academic Press New York. 361-400 pp.
- Chiseva, S. (2006). The growth rates and feed conversion ratios of fry fed conventional fry diets and *Moringa oleifera* supplemented diets. B.Sc. dissertation, Bindura University of Science Education, Zimbabwe.

- Fagbenro, O. A. Balogun, A. M. and Anyanwu, C. N. (1999). Optimal dietary protein level for *Heterobranchus bidorsalis* fingerlings fed compounded diets. *Israel Journal of Aquaculture Bamidach*, 44: 87–92.
- FAO, (2000). Report to the Government of Nigeria on experiments in brackish-water fish culture in the Niger Delta, Nigeria, 1965–68. Based on the work of K.K. Nair, FAO/UNDP (TA) Inland fishery biological Fish Culture). Rep. FAO/UNDP (TA), (2759); 14 pp. Farming 5, 1-2.
- FAO, (2006). Corporate Document Number 20. Rome, Italy: Food and Agriculture Organization of the United Nations.
- Ferreira Pmp, Farias Df, Oliveira Jta And Car- Valho Affu. (2008). Moringa oleifera: Bioactive compounds and nutritional potential. *Review in Nutrition*, 21: 431–437.
- Francis, G., Makkar, H.P.S. and Becker, K. (1999). Plant toxins and detoxification methods to improve and extract Moringa oleifera leaves. *Pakistan Journal of Nutrition*, 7(1)13-16
- Halver, J. E. (1989) The vitamins. In: Fish Nutrition (Halver, J. E., ed.), 2nd ed., pp. 32-109. Academic Press, San Diego,
- Harborne, J. B. (1973). Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis, Chapman and Hall, London, UK.
- Kakengi, A. M. V. Shem, M. N.; Sarwatt, S. V. and Fujihara, T. (2005). Can *Moringa oleifera* be used as a protein supplement for ruminants? *Asian Aust. J. Anim. Sci.*, 18 (1): 42-47
- Kasolo, J.N., G.S., Bimenya, L., Ojok, J., Ochieng and J.W. Ogwal-okeng (2010). Phytochemicals and uses of *Moringa oleifera* leaves in Ugandan rural communities, *J. Med. Plants Res.*, 4 (2010) 753–757
- Keay R. W. J, Onochie C. F. A and D. P. Stanfield (1964), Nigerian Trees, Department of Forest Research Publishers, Ibadan, Nigeria, 1964
- Maynard, L. A., Loosli, J. K., Hintz, H. F., Warner, R. G. (1979). *Animal nutrition* (7th ed) New York: McGraw-Hill, 1979.
- Miller, D.S. and Bender, A.E. (1955). The determination of the net protein utilisation by a shortened method. *British Journal of Nutrition*, 9: 382-388
- Schippers, R. R., (2002). African indigenous vegetables, an overview of the cultivated species
- Mgbenka B. O, Oluahns (2003). Effect of Gammalin 20 (Lindane) on the differential white blood cell counts of the African catfish, *Clarias albopunctatus*. *Bull of Environmental Contamination Toxicology*. 71:248-254
- Mbikay, M. (2012). Therapeutic potential of *Moringa oleifera* leaves in chronic hyperglycemia and dyslipidemia: a review, *Frontier Pharmacology*, 3 (2012)1–12
- Olson, M.E. (2010). Flora of North America Committee, ed. eFlora summary: Moringaceae: Drumstick Family. Flora of North America, North of Mexico. New York and Oxford.; 7:167–169
- Paliwal, R., Sharma, V. Pracheta, E. (2011). *Asian Journal of Biotechnology*, 2011, 3(4); 317-318
- Rana, K.J., Siriwardena, S. and Hasan, M.R. (2009). Impact of rising feed ingredient prices on aquafeeds and aquaculture production. In: FAO fisheries and aquaculture technical paper, Vol. 541. FAO, Rome
- Roberts R. J. (1978). Fish Pathology. *A Bailliere Tindall Book*, Publ. Cassell Ltd, 1978.
- Richter, N., Siddhuraju, P. and Becker, K. (2003). Evaluation of nutritional quality of moringa (*Moringa oleifera* Lam.) leaves as an alternative protein source for Nile tilapia (*Oreochromis niloticus* L.). *Aquaculture*, 217: 599-611.
- Shah, S.L. and Altindag, A. (2004). Haematological parameters of tench (*Tinca tinca* L.) after acute and chronic exposure to lethal and sublethal mercury treatments. *Bulletin of Environmental Contamination and Toxicology*. 73: 911 – 918.
- Soetan K. and Oyewole O. (2009). The need for adequate processing to reduce the antinutritional factors in plants used as human foods and animal feeds: A review. *African Journal of Food Science*, Vol. 3 (9), pp.223-232.
- Tacon, A.G.J., Hasan, M.R. and Subasinghe, R.P. (2006). Use of fishery resources as feed inputs to aquaculture development: Trends and policy implications. In: FAO fisheries circular, Vol. 1018. FAO, Rome.
- Thurber, M.D. and Fahey, J.W. (2010). Adoption of *Moringa oleifera* to combat undernutrition viewed through the lens of the diffusion of innovations theory. *Ecology, Food Science and Nutrition*, 48 1–13.
- Yue, Y.R. and Zhou, Q. C. (2008). Effect of replacing soybean meal with cotton seed meal on growth, feed utilization and haematological indices for juvenile hybrid tilapia *Oreochromis niloticus* x *O. aureus* *Aquaculture*, 284 – 185 – 189

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The Roles of Additives in Aquafeed for sustainable Aquaculture Production in Nigeria

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Abstract

Aquaculture is one of the most developing and fast growing food producing sectors worldwide, and it contributes immensely to the global production of fish. In aquaculture operations, nutrition is the major crucial factor determining the potential of cultured fish to exhibit its capability for growth and reproduction in the culture medium. In recent years, application of additives in fish feed production have been on the increase due to intensification and expansion of fish farming activities. Feed additives are substances which are added in trace amounts in fish diet; it also, acts as ingredients improver or preserver. They are the essential compound of the fish diet. The use of feed additives in the animal's diet plays a vital role to rising growth and immunity of the aquatic animals. The major feed additives act as preservatives, binders, feeding stimulants, and food colorants etc. The use of additives must be in correct amount, the requirement of additives depends on species and their availability. The role of feed additives is to control the pathogenic microbes, enhance their growth, immune stimulation, and ensure water quality. For these reasons, several types of dietary feed additives are used in aquaculture, these include essential oil, essential fatty acid, probiotics, prebiotics, symbiotic, and exogenous enzymes. These additives are considered to be useful for their specific medicinal properties and eco-friendly metabolism in the digestive system. This review describes the role of various feed additives and their relevance to aquaculture production.

Keywords: Aquaculture, Additives, Aqua feed, Fish nutrition

Introduction

Fishes are one of the excellent and inexpensive sources of essential protein and more than half of the population in the world relied on fish for dietary protein source. In the past decade, high importance has been accorded to fish production and their nutrition. Nutrition is the major crucial factor determining the potential of cultured fish to exhibit its genetic capability for growth and reproduction. (Oramary *et al.*, 2016). Good nutrition in animal production systems is essential to economical production of a healthy, high-quality product. Nutrition is one of the critical factors in aquaculture, feed alone represents around 50 – 80% cost of production in aquaculture. Successful aquaculture depends on a nutritionally balanced diet and low cost of production. The nutritional quality and cost of the feed depending on the price and quality of the feed ingredients and additives which is used for feed formulation (Dada, 2015).

Feed ingredients are a mixture of both organic and inorganic components. These components are varied based on the raw material and their extraction process. Fish nutrition has advanced dramatically in recent years with the development of new, balanced commercial diets that promote optimal fish growth and health. The development of new species-specific diet formulations supports the aquaculture industry as it expands to satisfy increasing demand for affordable, safe, high-quality fish and seafood products. Feed additives are added during feed preparation to improve the quality of the feed and health performance, feeding efficiency of the fishes (Gabriel *et al.*, 2007). The increased in costs and short quantity of fish feed have given reason to the need to increase research for substitutes (Crowther, 1992). Therefore, the fish feeds require to be enriched with additives.

Aquaculture and the Need for Feed Additives

As a developing agricultural sector, aquaculture has been contributing significantly to the development of global production. Nigeria holds the second position in aquaculture production in Africa after Egypt compared to other countries. Fisheries and aquaculture play an important role in economic development, and in this context, sustainable agriculture and fisheries, together with aquaculture, remain key divers for poverty eradication and sustainable development (Farahiet *et al.*, 2012; Okomoda *et al.*, 2017). In the past decades, aquaculture farms have used many antibiotics, chlorides, and other substances, which negatively impact the environment (Shin and Kim, 2004; Shalaby *et al.*, 2006; Oz *et al.*, 2017). Therefore, this has spurred several researchers and biotechnology companies

to develop an eco-friendly feed additive. The goal of use of these feed additives in aquaculture is to enhance fish quality and also ensure that the health of the consumers is not adversely affected (Sivaram *et al.*, 2004).

Feed additives represent various classes of molecules, compounds, or organisms that promote ingestion, absorption, assimilation of nutrients, growth, and health. They affect physiological processes, such as immune function, stress resistance, and reproduction. Feed additives include feeding attractants, immunostimulants, prebiotics, probiotics, acidifiers, essential oils, or other inclusions. These additives are usually not required nutrients. A wide range of feed additives used to fulfil nutritional requirements targets healthy growth as well as feed utilization and stress resistance in an aquaculture species (Encarnação, 2016). The use of antibiotics in livestock (Balasubramanian *et al.*, 2018; Kwang Yong *et al.*, 2018) as well as in aquaculture feed to mitigate infectious diseases or to boost growth performance is common. Even chemical-based antibiotics and synthetic minerals can cause considerable side effects and adversely affect water quality (Hoseinifar *et al.*, 2019). Therefore, eventually, these were banned from use in aquaculture by law in many countries. Certain probiotics and prebiotics can promote proper digestion, increase immune response, and retain water quality, and act as promoters of aquatic animal growth, survival, and health (Dash *et al.*, 2018).

Description of Feed Additives

Feed additives are substances which are added in trace amounts to a diet or feed ingredient to improve or preserve it. Major feed additives also act as preservatives, binders, feeding stimulants, and food colorants. An ingredient or combinations are added to the basic feed mix to fulfil a specific need and usually used in micro quantities. For making the feed more attractive, palatable and digestible- attractants, flavours and digestive aids are added. Binding materials are used to prevent disintegration of feed under water column. Feed devoid of nutrient ingredients are additives that are incorporated in diets for reasons other than to offer nutrients (Dawood *et al.*, 2018). For the most part, these compounds have little or no nutritional value, yet they are important constituents of fish feeds, increasing pellet stability, diet safety, diet flavour, and animal and fish performance and health status and influencing the quality of the final product (Figure 1). Non-nutritive feed ingredients include feed binders, carotenoid supplements, drugs and antibiotics, hormones, antifungal, antioxidants, fibre, flavourings, and water (Yadav *et al.*, 2019).



Figure: Schematic Diagram of Additives in Aquaculture

Source: Vignesh *et al.* (2022)

Classification of Additives

There are three general categories of additives for use in aquaculture; Nutritional additives, Processing agents and Preservatives, also sensory agents. These are not strict classifications, as many additives fall into more than one category. For more information on additives, see emulsifier; food colouring; nutritional supplement; and preservative. According to Soetan *et al.* (2010), the main objective of additives in feed is to achieve healthy and faster growth of fish in the culture medium leading to higher production. The various additives used for these purpose may be classified into:

1. Essential additives.
2. Growth promoting but non-essential additives.
3. Auxiliary additives.

A. Essential feed additives:

They are supplemented in small quantities to make the formula nutritionally better balanced to promote healthy growth. Their prolonged absence in feed may result in one deficiency disease, abnormalities or retarded growth (Luo *et al.*, 2005).

These essential additives are as follows:

1. Vitamins

Vitamins are organic compounds essential in fish diets for their normal growth and health; they should be administered in the diet as fish are not able to synthesize them. Within the water-soluble vitamins, vitamin C is the most important in fish nutrition for its antioxidant and immune stimulant effect. Deficiency of ascorbic acid (vitamin C) will cause scoliosis, while folic acid (vitamin B9) deficiency will cause a dark coloration. Regarding fat-soluble vitamins, vitamin E is of a greater importance also because of its role as an antioxidant. The vitamin requirements in cultured aquaculture species are highly **variable depending on the species and life cycle phase (Elazig et al., 2015)**.

2. Minerals

Minerals are inorganic elements necessary for the proper functioning of the organism of fish. Macro minerals (of which higher doses are needed), which are sodium, chlorine, potassium and phosphorus, regulate the maintenance of colloidal systems (osmotic pressure, viscosity and diffusion) and assist in the formation and maintenance of bones. The micro minerals are copper, chromium, zinc, selenium and iodine, they are necessary for **proper enzyme and hormonal functioning**. Fish are able to capture minerals from two sources; the **environment**, through the gills, and **feed**. Mineral requirements vary between marine and freshwater fish, because, in the marine environment, the number of ions present is higher than in freshwater. Therefore, the supply of minerals in feed is more important in freshwater aquaculture species (Manaf *et al.*, 2016).

3. Fish oils

Fish oil is widely used in aquafeed production due to its richness in n-3 long-chain polyunsaturated fatty acids, particularly eicosapentaenoic (EPA) and docosahexaenoic (DHA) acids, the balanced fatty acid composition and effect of inducing strong feeding response in aquatic animals (Kapute *et al.*, 2016).

B. Growth Promoting Additives

These are classes of additives that promote the growth of fish in the culture medium. They are added in small quantities, to enhance fish growth in a short possible time.

1. Hormones

Various natural and synthetic hormones have been used in aquaculture for

- i. Inducement of spawning,
- ii. Sex reversal,
- iii. Production of mono-sex population,
- iv. Growth enhancement.

Hormones responsible for fish growth are growth hormone, thyroid hormone, gonadotropin, prolactin, insulin and various steroids. Steroid hormones- androgen, estrogens and progestogens and non-steroidal hormones thyroxine are used as growth promoters (Naiel *et al.*, 2020).

2. Enzyme:

Enzymes often used in aquaculture include protease, amylase, lipase, esterase, cellulase, xylanase and urease. They are used because they can increase the availability of nutrients, improve nutrient absorption in the digestive system, and drive faster fish growth rates (Kavitha *et al.*, 2015).

3. Probiotics

Probiotics are live microbial feed supplements that stimulate fish growth by affecting the microbial flora population in the gut. Probiotic may be a single species of microorganisms or a mixture of species. The species of microorganisms present in the supplement colonizes the gut and detrimental species of microorganisms. Allowing

the fish are to avoid wasting metabolic energy fighting the effects of detrimental organisms. Probiotics must be added to the feeds after pelleting (Kavitha *et al.*, 2015).

4. Prebiotics

Prebiotics are mostly fibers that are non-digestible food ingredients and beneficially affect the host's health by selectively stimulating the growth and activity of some genera of microorganisms in the colon, generally lactobacilli and bacteria (Jana *et al.*, 2018).

5. Synbiotics

A symbiotic product beneficially affects the host in improving the survival and implantation of live microbial dietary supplements within the alimentary canal by selectively stimulating the expansion.

6. Phytobiotic

The phytobiotic canister is regarded as plant-derived foodstuffs inoculation to feed in ranges to improve performance in aquatic species. Generally the plants leaves, roots, tubers, and fruits of herbs, spices and other plants also used as pytobiotics. The pytobiotics menially used to enhance the growth performance in fish and shrimp culture (Hardy and Barrows, 2003).

C. Auxiliary additives:

These are group of additives that are needed in smaller quantities. They act as components to the physical properties of feed. This in turn helps in better utilization of feed resulting in feed efficiency. Such additives may be considered as auxiliary additives. These are feed colour, binders, molasses and fats. Ex. Attractants, Colour, Binders, Molasses, etc

1. Feed colorants:

Over 300 pigments are found in various plant and animals. Carotenoids and astaxanthins are either present in some natural or as synthetic substances. Xanthophyll and carotenoids are being the most important classes of pigments. Most part xanthophyll are found in plants and carotenoid pigments are in crustaceans and in fish (Wagse *et al.*, 2018).

2. Binders

Fish feed must be strong enough to withstand normal handling and shipping without disintegration. Moreover, fish feed must be somewhat water-stable. Starch present in basic feed ingredients is gelatinized during processing and act as binder in feed. Materials such as agar-agar, carboxymethylcellulose (CMC), bentonite, guar gum, lignin sulfate, plaster of Paris, polyvinyl alcohol, sodium alginate and wheat gluten are used as binder. Used at 2 to 8 % level for higher stability of pellets (Hardy and Barrows, 2003).

3. Molasses

Addition of molasses to feed often helps in smooth pelleting of feed. Also improves its palatability. It is also a good source of energy in feed (Fiala, 1977).

Roles of Feed Additives in Aquaculture

1. They improves stability and texture of the fish feed.
2. It helps in nutrient availability, absorption and digestion in fish
3. They supply needed nutrients for fish growth and performance in aquaculture
4. They improve fish health by strengthening their immunity against invading pathogens.
5. They increase the economic value of fish
6. They enhances attractiveness and palatability of fish feed.
7. Improves the gut function of fish.
8. Enhances good water quality in the culture medium.
9. Regulates the maintenance of colloidal system
10. It helps the fish to maintain homeostasis

Conclusion

Feed additives, are generally used for higher productivity and enhancement resistance to infectious disease, which would ultimately lead to sustainable aquaculture. The various additives used for these purpose may be classified in

to essential additives, growth promoting but non-essential additives, and auxiliary additives. Major feed additives; preservatives, binders, feeding stimulants and food colorants and they are incorporated in feed to achieve healthy and faster growth leading to higher production. Hence, understanding the interactions of functional feed additives in the feeds and the biochemical & physiological functions of the animal is key for the further development of functional feeds. Finally it can be concluded that feed additive are added in feed to enhance growth and production, to make diet more attractive, more palatable and digestible- attractants, flavors and increase digestibility of fish in the culture medium.

References

- Agbabiaka L. A., Kuforiji, O. A. & Egobuike, C. C. (2016). Comparative studies on the nutrients, sensory and storage qualities of moon-fish (*Citharinus citharus* Geoffery Saint-Hilaire 1809) pre-treated with extracts from two spices. *Journal of Aquaculture Research and Development*, 7(2): 112-120.
- Bell J. G., Mcevoy J., Tocher D.R., Mcghee F., Campbell P. J. & Sargent J. R. (2000). Replacement of fish oil with rapeseed oil in diets of Atlantic salmon (*Salmo salar*) affects tissue compositions and hepatocyte fatty acid metabolism. *Journal of Nutrition*, 131, 1535- 1543.
- Buffum, J. (1982). Pharmacosexology: the effects of drugs on sexual function—a review. *Journal of Psychoactive Drugs*, 1982; 14(1-2), 5-44.
- Crowther, J. B. (1992). Fish meal and oil: Current uses. *Journal of the American Oil Chemists Society*, 69(3), 221-227.
- Dada A. A. (2015). Improvement of tilapia (*Oreochromis niloticus* Linnaeus, 1758) growth performance fed three commercial feed additives in diets. *J Aquac Res Development*, 6(325), 2.
- Dawood, M.A., Koshio, S. and Esteban, M.Á., (2018). Beneficial roles of feed additives as immunostimulants in aquaculture: a review. *Reviews in Aquaculture*; 10(4), 950-974.
- Elazığ, I., Fotedar R. & Buller, N. (2015). Survival and immunity of marron *Cherax cainii* (Austin, 2002) fed *Bacillus mycoides* supplemented diet under simulated transport. *Journal of Aquaculture Research and Development*, 7(1), 1-6.
- Farahi A., Kasiri M., Sudagar, M., Soleimani Iraei M. & Zorriehzahra S. M. J. (2012). Effect of dietary supplementation of *Melissa officinalis* and Aloe vera on hematological traits, lipid oxidation of carcass and performance in rainbow trout (*Oncorhynchus mykiss*). *Online Journal of Animal and Feed Research*, 1, 1-5.
- Hardy, R.W. and Barrows, F.T., (2003). Diet formulation and manufacture. In *Fish nutrition*. 505-600, Academic Press.
- Jana, P., Karmakar, S., Roy, U., Paul, M. and Bera, A.K.S.K.K., (2018). Phytobiotics in aquaculture health management: A review. *Journal of Entomology and Zoology Studies*, 6(4), 1422-1429.
- Kapute F., Msiska O. V., Kang'ombe J. S., Mzengereza K., Kamangira A. & Singini, W. (2016). Apparent Nutrient Digestibility of Plant Based Diets by *Tilapia rendalli* (Boulenger, 1896). *Journal of Aquaculture Research and Development*, 7(3) 123-130.
- Kavita. R. Pandey, Suresh. R. Naik, and Babu. V. Vakil, (2015). Probiotics, prebiotics and synbiotics- a review. *J Food Sci Technol.*; 52(12): 7577–7587.
- Luo, X.G., Ji, F., Lin, Y.X., Steward, F.A., Lu, L., Liu, B. and Yu, S.X. (2005). Effects of dietary supplementation with copper sulfate or tribasic copper chloride on broiler performance, relative copper bioavailability, and oxidation stability of vitamin E in feed. *Poultry Science*, 84(6), 888-893.
- Manaf S. R., Daud H. M., Alimon A. R., Mustapha N. M., Hamdan R. H., Muniand K. G., Mohamed N. F. A., Razak R. & Hamid, N. H. (2016). The Effects of *Vitex trifolia*, *Strobilanthes crispus* and Aloe vera Herbal-mixed Dietary Supplementation on Growth Performance and Disease Resistance in Red Hybrid Tilapia (*Oreochromis sp.*). *J Aquac Res Development*, 7(425), 2.
- Naiel, M.A., Shehata, A.M., Negm, S.S., Abd El-Hack, M.E., Amer, M.S., Khafaga, A.F., Bin-Jumah, M. and Allam, A.A. (2020). The new aspects of using some safe feed additives on alleviated imidacloprid toxicity in farmed fish: a review. *Reviews in Aquaculture*, 212: 188-199.
- Okomoda, V.T., Tihamiyu, L.O. and Akpan, I.S., (2017). Nutritional evaluation of toasted *Mucuna utilis* seed meal and its utilization in the diet of *Clarias gariepinus* (Burchell, 1822). *Journal of Applied Aquaculture*, 29(2): 167- 182.
- Oramary S. O. M., Koramarky D. M. I., Salih S. A. & Mustafa A. A. (2016). Feeding Common Carp Fish (*Cyprinus carpio*) on Natural Foods (Algae, Phytoplankton, Zooplankton and Others) on Tigris River in Mosul Dam/Duhok, Kurdistan Region of Iraq. *J Aquac Res Development*, 7(413), 2.

- Öz M., Dikel S., Durmuş M. & Özoğul Y. (2017). Effects of Black Cumin Oil (*Nigella sativa*) on Sensory, Chemical and Microbiological Properties of Rainbow Trout during 23 Days of Storage at 2±1 C. *Journal of Aquatic Food Product Technology*, 26(6), 665-674.
- Shalaby A. M., Khattab Y. A. & Abdel Rahman A. M. (2006). Effects of Garlic (*Allium sativum*) and chloramphenicol on growth performance, physiological parameters and survival of Nile tilapia (*Oreochromis niloticus*). *Journal of Venomous Animals and Toxins including Tropical Diseases*, 12(2), 172-201.
- Shin S. H. & Kim M. K. (2004). Effect of dried powders or ethanol extracts of garlic flesh and peel on lipid metabolism and antithrombogenic capacity in 16-month-old rats. *Journal of Nutrition and Health*, 37(7), 515-524.
- Sivaram V., Babu M. M. Immanuel G., Murugadass S., Citarasu T. & Marian M. P. (2004). Growth and immune response of juvenile greasy groupers (*Epinephelus tauvina*) fed with herbal antibacterial active principle supplemented diets against *Vibrio harveyi* infections. *Aquaculture*, 237(1-4), 9-20.
- Soetan, K.O., Olaiya, C.O. and Oyewole, O.E. (2010). The importance of mineral elements for humans, domestic animals and plants-A review. *African Journal of Food Science*, 4(5), .200-222.
- Wagde, M.S., Sharma, S.K., Sharma, B.K., Shivani, A.P. and Keer, N.R. (2018). Effect of natural β -carotene from carrot (*Daucus carota*) and Spinach (*Spinacia oleracea*) on colouration of an ornamental fish - swordtail (*Xiphophorus hellerii*). *Journal of Entomology and Zoology Studies* 6(6): 699-705.
- Yadav, M.K., Ojha, M.L., Keer, N.R. and Yadav, A. (2019) An overview on the use of oil in fish diet. *Aquaculture*, 7(1): 883-885.

**GEAR TECHNOLOGY,
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AND
INDUSTRIAL FISHERIES**

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Effect of Socio–Economic Characteristics On Income Of Kize Fisher Folks In Katsina /Ala Local Government Area, Benue State

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Abstract

Fishing is one of the commercial activities that are carried out in Katsina- Ala, Benue State. This activity provides a reasonable income for the farmers as well as high quality protein for the consumers of fish. Recently, Fisher men/women are faced with the problems associated with restrictions in movement, occasioned by COVID 19 pandemic. The survey was conducted to determine the effect of socio-economic characteristics on income of Kize fisher folks in Katsina - Ala local government area, Benue State, amid COVID 19. The study adopted a qualitative study design. The population of this study consisted of all members of Kize fisher folks in Katsina -Ala. However, a sample size of 117 respondents was selected using, snowball and simple random sampling techniques. Data for this study were collected from primary and secondary sources, mainly through the use of a structured questionnaire along-side interview technique. The data were analyzed using descriptive statistics as well as inferential statistic. The results of the analysis showed that 72.65% of the respondents were in the age bracket of 21-50 years. The result also showed that there were 54.10% male and 45.90% female. The respondents also earned a reasonable (> ₦ 100,000.00) income. Many (50.00%) of the respondents had low access to fishing equipment. The hypothesis which states that “respondents’ selected socio-economic characteristics do not significantly influence their income from fishing” was tested and rejected at 5% level of significance. It was concluded that socio- economic characteristics of the respondents significantly affected their income level from fishing and they had several challenges bothering on poor price of fish and credit facilities. It is therefore, recommended among others, that respondents should be allowed access to credit facilities in order to expand their business.

Keywords: Socio – economic, Characteristics, Income, Kize, Fisher Folks

Introduction

Fish is the most reliable source of protein for many people in the developing countries (Olasunkanmi, 2013). Fish farming has the potential to significantly contribute to poverty alleviation through income generation, creation of jobs, and enhanced food security (FAO, 2006). Fish farming development is credited with stimulating the development of rural communities in which they are located. It is recognized for the provision of important livelihood opportunities for the rural poor by improving the local household food security and livelihoods (Kundu, 2010). According to Joyce (2018), fish farming improves the lives of its citizens through enhancing the sectors’ contribution to wealth creation, increased employment for youth and women, food security and improves the economy through foreign exchange earnings of fish exports. Kundu (2010) recognized that social factors such as gender, age, education level and household characteristics play an important role in sustainable fish farming and income of farmers.

Fishing like other hunting activities has been a major source of food for the human race and has contributed to the reduction of the unsavory outbreak of anemia, kwashiorkor and other ailments due to malnutrition (Cheeke, 2002). Small- scale fishing has continued to develop steadily with several poor families and communities relying heavily on fishing as a livelihood (Gatonye, 2017). This steady development has however been hampered by the outbreak of Covid 19. Kize is a fishing community located at the outskirts of Katsina- Ala town, having a relatively big lake flowing into the Kastina- Ala River. Both the lake and the river aid and facilitate their fishing activities in the sparse populated fishing community. Almost 90% of the dwellers are engaged in fishing activities. Each stage of the fisheries and aquaculture supply chain is susceptible to being disrupted or stopped by measures arising from COVID-19 restrictions (FAO, 2020). Fishing by the rural Kize fisher folk is not spared. Only by understanding and protecting each stage of the supply chain, can the continued availability of fish and fish products be ensured.

Objectives of the Study

The specific objectives of this study were to:

- i. describe the socio-economic characteristics of fisher men/women in the study area,
- ii. describe the level of fisher folks access to fishing equipment and
- iii. identify problems faced by the respondents.
- iv.

Statement of Hypothesis

H₀ : Respondents' selected socio-economic characteristics do not significantly influence their income from fishing.

Materials and Methods

Study Area

Katsina-Ala Local Government, on the map of Benue State lies 126km away from Makurdi, the Benue State capital. It is found in the North Eastern part of Benue State which is located on longitude 7° and 8° North of the equator and between latitude 7° and 10° east of the Greenwich Meridian (GWM). The LGA has an area of 2,402 km² and a population of 224,718 at the 2006 Census (Benue State Govt, 2012). There are different ethnic groups in Katsina-Ala with major ones being Tiv, Hausa, and Etulo. Katsina-Ala Local Government Area is predominantly an agrarian society. One of the major occupations in the local government area is fishing as there are several bodies of water in Katsina-Ala, including river Katsina-Ala.

Population and Sample Size Selection

The population of this study consisted of 230 members of Kize fish farmers in Katsina- Ala local government area. A total of one hundred and ten respondents were randomly selected using snowball and simple random sampling techniques.

Method of Data Collection

Data for this study were collected from both primary and secondary sources. Primary data were collected through structured questionnaire administered to the respondent's along-side interview techniques. The secondary sources of data included library textbooks, newspapers, journals, conference papers, office documents, and the internet.

Techniques of Data Analysis

Data for this study were analyzed using descriptive statistics, which were frequency and percentages as well as inferential statistics, which was Logistic regression model. Frequency and percentages were used to analyze objectives 1, 2 and 3, Logistic regression model on the other hand, was used to test the hypothesis.

Models Specification

Logistic Regression for hypothesis

The explicit form of the Logit regression function as applied in this study is presented as follows:

$$Y = \alpha + \beta_{1\log} X_1 + \beta_{2\log} X_2 + \beta_{3\log} X_3 + \beta_{4\log} X_4 + e$$

Where;

Y= Income

α = Constant

X_1 = Age

X_2 = Sex

X_3 = Marital status

X_4 = Level of education

β =Coefficient of exogenous variables

e=error term

Results and Discussions

Socio-Economic Characteristics of the Respondents

The study reveals that majority (72.65%) of the respondents were within the age bracket of 21- 50 years, followed by 17.95% of the respondents who were 51 years and above. Only 9.40% of the respondents were between 15-20

years. These results imply that the respondents were in the productive age category, meaning that they were active and yet mature. The results also imply that most of the respondents have a longer time to continue in fishing to improve the nutritional and income levels of their families. Okwu *et al.* (2011) also reported that only 10.80% of their respondents were above 59 years. The result is also similar to the findings of Olasunkanmi (2012). The result also shows that there were 54.10% male and 45.90% female. The result which shows a higher number of male respondents indicates that males participate more in fish farming than females. This result is similar to the findings of Shitote *et al.* (2013) in Western Kenya where the researchers reported that there were 71.9% male and 28.1% female fish farmers.

On the marital status of the respondents, the result shows that, the highest number of the respondents (54.70%) were married and still staying with their spouses. Another (18.80%) were single. Also (9.40%) were widow, closely followed by respondents who were divorced and widowers, each accounting for 8.55% of the respondents. This result confirms a priori expectations that, most fisher men and women are married and that single people find it difficult to cope with the rigors of fishing. Similarly, Okunlola (2014) reported that 56.8% of the bee keepers were married and only 2.6% were widow.

A reasonable number (54.70%) of the respondents had no formal education. This is followed with 27.35% of the respondents who attended and obtained primary school certificate (FSLC). A few (17.95%) respondents had Post primary certificate. This result is similar with the report of Ofuoku *et al.* (2009) that had only 4.20% of the respondents that attended any tertiary institution. This result implies that the respondents are generally not educated and this may have effect on their managerial skills vis a vis income from fish farming.

On income, the highest number (64.60%) of respondents earned income greater than ₦ 100,000= per annum, this is followed by 26.50% of the respondents who earned between ₦ 51,000 and ₦ 100,000. Another 9.40% earned less than ₦ 51,000. The implication of the result to this study is that, the people can at least procure certain equipment they need for their fishing activities.

Distribution of Respondents Based on Level of Access to Fishing Equipment The result shows that whereas, 50.00% of fisher folk have low level of access to fishing equipment. About 37.63% of the respondents have moderate level of access to fishing equipment. A smaller 12.37% have high level of access to fishing equipment in Katsina- Ala local government area. This is probably because of poor sales resulting to low income.

Problems Faced By Kize Fisher Folks

The result shows that the following factors were identified by the respondents as been serious problems ($\bar{x} \geq 2$); lack of credit facilities, lack of technical training, poor price of fish, lack of modern processing equipment, and poor preservation techniques. Factors that were identified as been mild problems ($\bar{x} = 1.5 - 1.99$) were; handling difficulties and weather. Lastly, distance to the market, availability of buyers and labour cost were not problems ($\bar{x} = 1.0 - 1.49$) to the respondents. This result implies that the respondents have generally been facing a lot of problems doing business as far as fishing and fish processing were concerned. This result confirms the findings of Akangbe, *et al.* (2015) who reported that inadequate capital was the most severe (88.0%) constraint faced by fishermen in Ilorin, Kwara State. The poor price of fish is probably because fish was sold only to local consumers because of the restrictions in movement.

Influence of selected Socio – economic Characteristics on the Income From Fishing

Hypothesis 1. Respondent's selected socio economic characteristics (Age, Sex, Marital status, Level of education) do not significantly influence their income from fishing.

The result of Binary logistic regression shows that the Hosmer and Lemeshow test Chi-square of 4.78 (df =8) was not significant which implied that the model used was not significantly different from the standard model. In addition, the chi-Square of 55.03 (df=12) for model coefficient indicated that socio-economic characteristics included in the model were significantly related to the income of Kize fish farmers. Hence the null hypothesis was rejected. The result shows that marital status was significant at 1%, while years of education were significant at 5%. These factors were found to exert a significant influence on the income of fish farmers.

Specifically, the marital status was positive and significant (1.126). This implies that married fish farmers were more likely to have more income than their non married counterparts. This confirms a priori expectation. The

coefficient of years of education was positive and significant (.109), implying that a unit increase in years of education would probably increase the income by 10.9%.

Table 1: Binary Logistic Regression of the Influence of Socio – economic Characteristics on the Income of Fish Farmers

Socio-economic characteristics	B	S.E.	Wald	Df	Sig.	Exp(B)
Age	-0.025	0.021	1.386	1	0.239	.975
Sex	0.105	0.339	0.096	1	0.757	1.111
Marital status	1.126	0.427	6.953*	1	0.008	.324
Years of education	0.109	0.052	4.378**	1	0.036	1.116
Constant	1.531	1.084	1.993	1	0.158	4.623
Chi-square	55.031(df= 12)				0.000	
Hosmer and Lemeshow Test	4.778 (df=8)				.781	
Nagelkerke R ²	.242					

Source: Computer Print Out From Field Data, 2020

*Statistically significant at 1% level of significance; **Statistically significant at 5% level of significance

Conclusion and Recommendations

The result shows that the respondents were in the productive age category, meaning that they were active and yet mature and can continue in fishing to improve the nutritional and income levels of their families. Most fishermen were male who were married and staying with their spouses. A reasonable number of them however, had no formal education but were earning a reasonable income from fishing activities. Many respondents have low access to fishing equipment and are faced with so many challenges, especially, lack of access to credit and poor price of fish. The study concludes that marital status and level of education significantly influenced the income level of Kize fisher folks in Katsina/ Ala.

The following recommendations are made in order to improve on the activities of the fisher folks for enhanced income vis- a- vis their nutritional status;

1. The respondents should be trained on modern fishing and processing techniques.
2. Fisher folks should be encouraged to join any of the existing fishing associations and form cooperatives in order that they could access funds from financial institutions.
3. The respondents should be allowed access to credit facilities in order to cope with pandemic and expand their business.
4. Kize fisher folks should be provided with preservative equipments to avoid undue wastages.

References

- Akangbe, J. A., Ajiboye, G. E. and Komolafe, S. E. (2015). Effects of Improved Fish Production Technology on the Output of Fish Farmers in Ilorin, Kwara State, Nigeria. *Ruhuna Journal of Science*, 6: 50-62
- Benue State Gov't (2012). Benue State Government Diary, Produced by Benue State Ministry of Information and Orientation, Makurdi.
- Cheeke, P.R. (2002). Rabbit feeding and Nutrition. Rabbit Research Centre, Department of Animal Science, Oregon State University, Corvallis, Academic press Inc, .66pp.
- FAO (2020). The impact of COVID-19 on fisheries and aquaculture food systems Possible responses Information paper, November 2020
- FAO. (2006). The State of World Aquaculture. FAO Fisheries Technical Paper No 500. Rome, FAO. 2006
- Gatonye, W. M.(2017). Factors Influencing Sustainability of Small-scale Fish Farming Projects in Kenya: The Case of South Imenti Sub-county, Meru. MSc. Thesis, Dept. of Project Planning and Management, The University of Nairobi, 101 pp.
- Gazette (2009). Federal Republic of Nigeria, Vol.96, No. 2 Abuja. Available at <http://www.population.gov.ng/index.php>. Retrieved 30th December, 2019
- Joyce M. N. (2018). Status of Socio-Economic Parameters of Fish Farmers in Kitui Central Sub- County, Kitui County. *Quest Journals Journal of Research in Agriculture and Animal Science*, 5(1): 28–41.
- Kundu, R (2010) Assessment of Socio-economic factors affecting Small scale Fish farming in Busia District, Kenya, Eldoret, Kenya

- Ofuoku, A. N., Emah, G. N., Itedjere, B. E. (2011). Information Utilization Among Rural Fish Farmers in Central Agricultural Zone of Delta State Nigeria. *World Journal of Agricultural Science* 4 (5): .558 – 564.
- Okwu, O. J., Yahaya, M. A. and Obinne, C. P. O. (2011). Analysis of Artisanal Fisher Folk Information Needs and Accessibility in Benue State, Nigeria. *Asian Journal of Agricultural Sciences*, 3 (5): Pp.408-413
- Olasunkanmi, J. B. (2012). Economic analysis offish farming in Osun State. Presented at the 2Sth Biannual Conference of the Int'l Institute of Fisheries Economics & Trade (IIFET), July 15-17, Dar-es-Salaam, Tanzania.
- Olasunkanmi, J. B. (2013). Socio-economic Analysis of Fish Farming in Ogun State, Southwest Nigeria Proceedings of 28th FISON Annual Conference. 25th to 30th November p. 93
- Shitote, Z., Wakhungu, J., China, S., Likuyani, K.H., Okoth, P., Maina, J. and Wakaanya, M. (2013). Socio - economic Characteristics and Practices of Fish Farmers in Western Kenya. *Elixir International Journal* Available online at www.elixirpublishers.com . Accessed 12th December, 2020

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Catch Composition of Modified and Non-Modified Artisanal Purse Seine Nets in the Southern Basin of Lake Kainji, Niger State, Nigeria

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Abstract

Catch composition of modified and non-modified purse seine nets in the Southern Basin of Lake Kainji, Nigeria was studied for twelve months between April, 2020 and May, 2021. Each net was operated by two persons separately with two different canoes. A Randomized Complete Block Design was used with nets as factor of comparison and stations as blocks. A total of six artisanal nets replicated four times in each fishing trip. The results showed that a total of 35 fish species belonging to 13 families were caught with the Mochokidae (22.19%) family constituting the highest percentage in the Non-modified purse seine net (NMPSN), followed by Alestidae (18.91%), Citharinidae (15.65%) and the lowest family was Hepsetidae (0.36%) in NMPSN and in the Modified purse seine net (MPSN) the family Mochokidae (20.44%), still had the highest representation, followed by Alestidae (15.4%), Citharinidae (15.4%) and Hepsetidae (0.56%) the lowest. The three most dominant fish species were *Synodontis membranaceus* (8.86%), *Citharinus citharus* (7.44%) and *Hydrocynus forskalii* (6.33%) and least dominant species was *Hepsetus odoe* (0.47%). Modified purse seine net had the highest catch rate (3.26 ± 0.21 kg) and Non-modified purse seine net the least catch rate (1.85 ± 0.15 kg). There was significant difference ($P < 0.05$) between Modified purse seine net and Non-modified purse seine net. Based on the findings of this study, the Modified purse seine nets had better performance than Non-modified purse seine nets. The mean catch per unit effort values were higher in the Modified purse seine nets and lower in Non-modified purse seine nets.

Keywords: Catch composition, catch rate, purse seine nets,

Introduction

Fishing gear are equipment in the fishing system which are used in the harvesting or cropping of fish from any water body (Food and Agriculture Organization (FAO), 2012). The efficiency of fishing operations depends largely on the degree to which this fishing system is understood and controlled, its suitability to prevailing conditions, the mutual compatibility of its technical elements and the extent to which the gear parameters have been selected to exploit the characteristics of fish behaviour (FAO, 2005). Fishing gear is classified into two basic groups namely passive and active fishing gear. In passive fishing gear, the fish swims or moves voluntarily into the gear hence experience is needed to construct passive gear such as traps, hook and line, gill nets etc. In the case of an active fishing gear, the gear goes after the fish (Adjarho *et al.*, 2007). Active gears are designed to be dragged or towed in order to catch fish and examples include trawl net, cast net, spears, drift nets, purse seine nets etc (Grayet *et al.*, 2007). The choice of any fishing gear is dependent on several factors such as seasonal period of fishing, habit and habitat of the species sought and the particular water body as well as economic considerations (Kwen *et al.*, 2013). In Lake Kainji, the artisanal fishers rely greatly on fishing gear that are designed, fabricated and possibly modified to suit their particular fishing ground. One such popular fishing gear used in Lake Kainji is the artisanal purse seine net (Binyotubo *et al.*, 2016 and Kwen *et al.*, 2017).

Purse seine net is a surrounding net used in catching fish by surrounding school of fish (Earyrs, 2005). The purse seine net has a purse-like mechanism at the bottom of the net which is closed when hauling and retains most of the fish caught in the net (Adimula and Nasiru 2005). The net was introduced to Nigerians by Ghanaian Fishers for the capture of pelagic fishes such as Mochokids, Clariids, Mormyrids, Bagrids, Sardines, Mackerels, Herrings, Tunas, Threshers etc in Nigeria Inland and Coastal waters (Binyotubo, 2011). The artisanal purse seine nets commonly used in Nigeria have stretch mesh sizes ranging from 13.5-25mm, length 150-300m, and depth 20-30m (Binyotubo *et al.*, 2016). Adimula and Nasiru (2005) described artisanal purse seine net as an active fishing gear that “goes” after the fish population. The efficiency of this gear depends on the design and speed at which the gear can chase the fish population. Fishing with purse seine net is affected by many factors such as the materials used, design etc which

influence the efficiency and selectivity of the gear directly or via interaction with other factors (Cooke and Suski 2005).

The efficiency (catch-ability) of a fishing gear is defined as the proportion of total fish population of a certain size-class, which is caught and retained by a unit operation of the gear (Earys, 2005). Selectivity on the other hand is the relative efficiency per size-class (Caruthers *et al.*, 2009). Numerous factors often influence the catch-ability (efficiency) and selectivity of the gear, the biological characteristics such as fish's body size and shape, feeding habits, swimming speed, behaviour in the vicinity of fishing gear and during the capture process (Earys, 2005). Other factors are spatial distribution and aggregation behaviour of the target species. The non-modified artisanal purse seine nets are commonly used in Lake Kainji in Niger State by artisanal fishers because they are very efficient in terms of the number and weight of fish caught during fishing operations. These non-modified artisanal purse seine nets are constructed with ply 3 and ply 6 netting materials and as such their rate of entanglement are higher due to their smaller ply sizes. The modified artisanal purse seine nets are newly designed and constructed fishing nets in order to reduce the entanglement rate to control by-catch. The modified artisanal purse seine nets are constructed with ply 9 and ply 12 netting materials which are bigger than those of the non-modified artisanal purse seine nets materials. Studies have been carried out on the use of non-modified artisanal purse seine nets in Lake Kainji (Adimula and Du- Feu, 1998) but not much have been done on the modified artisanal purse seine nets. This study was therefore aimed at assessing the efficiency of the modified and non-modified artisanal purse seine nets in terms of fish catch composition and catch per unit effort in the Southern Basin of Lake Kainji, Niger State, Nigeria.

Materials and Methods

Study Area

This study was carried out at the Southern Basin of Lake Kainji in Niger State, Nigeria. Kainji Lake is the second largest lake in West Africa after Lake Volta (Nuhu and Yaro, 2005) and also the largest man - made lake in Nigeria (Adimula and Nasiru 2005). It is situated between latitudes 9° 50' 10° 57' North and longitudes 4° 25' 4° 45' East. The Lake was impounded in August 1968, it is now 134 km in length and 24 km in width. Its surface area has been variously quoted as approximately 1,270 km² (Du-Feu and Abiodun, 1998), a volume of 13 × 10⁹ m³, and catchment's area of 1.6 × 10⁶ km² (Obot, 1989). The climate of the study area usually alternates between dry and rainy season. The area has total annual rainfall of between 1,270 mm and 1,524 mm and spread over the month of April to October (Nuhu and Yaro, 2005). The highest amount of rainfall is usually observed in August with an average annual rainfall of about 860mm which is usually distributed between the months of June and October (Abiodun, 1973). Monthly temperature is usually highest in March at about 30°C and lowest in August at about 25°C (Nuhu and Yaro, 2005). The number of fishing settlements in Kainji Lake is about 314 (Abiodun and Ayanda, 2008). The Lake is situated in the southern portion of River Niger extending through the Guinea and Sudan savanna, which is characterized by grasses and fire resistant trees and shrub (Richard *et al.*, 2010). The main purpose of making the impoundment was the generation of Hydro-electric power. The lake opened, however, massive opportunities for different kinds of developmental projects such as fisheries, irrigation, and improved the navigation on River Niger (Federal Department of Fisheries, 2008).

Selection of the Sampling Stations

Selection of the sampling stations was based on preliminary investigation from the artisanal fishers along the Southern Basin of Lake Kainji. The selection was greatly influenced by the fishing activities in those villages. The fishing villages selected were Yuna (station 1) Kaya (station 2) and Anfani (station 3). The villages are 2-5 km apart and are the major fish landing sites along the Southern Basin of Lake Kainji. The geographic position of each station was obtained using a Germin 12 Global Positions System Receiver (GPSR).

Experimental Design

The experimental design for the study was a Randomized Complete Block Design (RCBD) with nets as factor of comparison (treatment) and stations as blocks. A total of six artisanal purse seine nets were used comprising one each of the modified and non-modified artisanal purse seine nets replicated four times in each fishing trip.

Field Sampling Procedure

The study was carried out between April 2019 and March 2020 in the Southern Basin of Lake Kainji, Niger State, Nigeria using the Non-modified and Modified artisanal purse seine nets. The purse seine nets were taken to the

fishing site, and were set by four crew members, with one person in each canoe (wooden canoe) separately making a total of four canoes per station. One net was operated by two persons separately. This operation results in the formation of a rough circle. First, the burnt end of the net and the purse line are fastened to the buoy. Then the purse seiner moves in encircle, paying out the net, to reach back to the buoy attached to the first end of the net set. Once the encircling is completed, the purse line is drawn with the help of a double capstan or other type of line hauler. On completion of the pursing operation, the lead line is bunched on the surface, closing the net and preventing the fish from escaping. Then the net is hauled on board, starting from the wings end so as to gradually drive the fish into the bunt, of which the float line has already been lifted and kept away from the side of the boat. The brailing of the catch is done with large scoopnets, which is often hand operated. Each net was trawl four time in each station giving a total of four trawls. The nets were haul after 40 minutes and fish caught were remove and identified using fish identification field guide by Olaosebikan and Raji (2013) into their different families and species based on the gear that caught the fish.

Data Analysis

The data collected on fish number, weight and length were subjected to T-test for comparing the nets and Analysis of Variance(ANOVA) for comparing the stations (Steel and Torrie, 1980), using the statistical package for the Social Sciences(SPSS, 1999). Mean values were separated using Duncan Multiple test (to test if there were any significant differences).

Catch per unit effort

The catch per unit effort(CPUE) was determined using the formula:

$$CPUE = \frac{NUMBER/WEIGHT\ OF\ FISH\ CAUGHT}{EFFORT} \text{ (Ahmed et al., 2006)}$$

Where:

Effort = The product of the number of fishers operating the fishing gear and the time in hours.

Results

Fish Catch Composition

The different families and species of fish caught by the non-modified and modified artisanal purse seine nets are presented in Table 1. A total of 35 fish species belonging to 13 families were caught during the study. The highest number of fish species (21.20%) was observed in the family Mochokidae with five species (*Synodontisbatensoda*, *Synodontisclarias*, *Synodontisfilamentosus*, *Synodontismembranaceous* and *Synodontis vermiculata*), followed by Alestidae (16.93%) with five species (*Alestesdextex*, *Alestes nurse*, *Hydrocynusvittatus*, *Hydrocynusbrevis* and *Hydrocynusforskalii*), Citharinidae (15.51%) with three species (*Citharinusdistichodus*, *Citharinuscitharus* and *Citharinuslatus*), Claroteidae (9.49%) with three species (*Chrysichthysfilamentosus*, *Chrysichthysnigrodigitatus* and *Claroteslaticeps*), Cyprinidae (9.18%) with two species (*Labeocoubie* and *Labeosenegalensis*), Distichodontidae (7.59%) with four species (*Distichodusrostratus*, *Distichodusbrevipinus*, *Distichodus engycephalus* and *Distichodusrume*), Bagridae (6.96%) with two species (*Bagrusbayad* and *Bagrusfilamentosus*), Latidae (5.22%) with one species (*Latesniloticus*), Mormyridae (3.01%) with four species (*Mormyrus delicious*, *Mormyrusrume*, *Mormyrussenegalensis* and *Mormyrustapirus*), Arapaimidae (1.74%) with one species (*Heterotisniloticus*), Cichlidae (1.58%) with three species (*Oreochromisniloticus*, *Sarotherodonniloticus* and *Tilapia zilli*), Gymnarchidae (1.11%) with one species (*Gymnarchusniloticus*) and Hepsetidae constituted 0.47% of the total catch with one species (*Hepsetusodoe*). The three most dominant fish species recorded were *Synodontis membranaceous*, *Citharinus citharus* and *Hydrocynus forskalii* having a percentage of 8.86%, 7.44% and (6.33%) respectively and the least dominant fish species recorded was *Hepsetus odoe* with 0.47%. In terms of the family of fish caught, the family Mochokidae 22.19% had the greatest representation in the Non-modified purse seine net (NMPSN), followed by Alestidae 18.91% (NMPSN), Citharinidae 15.65% (NMPSN) and the lowest family was Hepsetidae 0.36% (NMPSN) and in the Modified purse seine net the family Mochokidae (20.44%), still had the highest representation, followed by Alestidae 15.4%, Citharinidae (15.4%) and Hepsetidae 0.56%.

In terms of the various fish species caught in both Non-modified and Modified purse seine nets during the study. It shows that *Synodontis membranaceous*(7.64%), *Citharinus citharus* (7.27%) had the highest representation and *Hepsetus odoe* (0.36%), *Distichodus rume* (0.36%), *Distichodus engycephalus*(0.36%) and *Oreochromis niloticus*(0.36%) had the least representations for the Non-modified purse seine net (Table 1). For the Modified purse seine net, it revealed that, *Synodontis membranaceous* (9.80%), *Citharinus citharus*(7.56%), *Chrysichthys*

filamentosus (6.44%) had the highest representation and *Alestes nurse* (0.28%), *Tilapia zilli* (0.28%), *Distichodusengycephalus*(0.28%)and*Mormyrus delicious*(0.28%) had the least representation (Table 1).

Table 1: Family and species of fish caught by the various nets

Family	No.	%	Fish species identified	Total number of fish species caught		NET TYPE			
				No.	%	Non-modified artisanal purse seine net		Modified artisanal purse seine net	
Alestidae	107	16.93	<i>Alestes dentex</i>	18	2.85	9	3.27	9	2.52
			<i>Alestes nurse</i>	8	1.27	7	2.55	1	0.28
			<i>Hydrocynus vittatus</i>	6	0.95	2	0.73	4	1.12
			<i>Hydrocynus brevis</i>	35	5.54	14	5.09	21	5.88
			<i>Hydrocynus forskalii</i>	40	6.33	20	7.27	20	5.60
Bagridae	44	6.96	<i>Bagrus bayad</i>	19	3.01	9	3.27	10	2.80
			<i>Bagrus filamentosus</i>	25	3.96	10	3.64	15	4.20
Cichlidae	10	1.58	<i>Oreochromis niloticus</i>	5	0.79	1	0.36	4	1.12
			<i>Sarotherodon niloticus</i>	2	0.32	0	0.00	2	0.56
			<i>Tilapia zilli</i>	3	0.47	2	0.73	1	0.28
Citharinidae	98	15.51	<i>Citharinus distichodus</i>	23	3.64	7	2.55	16	4.48
			<i>Citharinus citharus</i>	47	7.44	20	7.27	27	7.56
			<i>Citharinus latus</i>	28	4.43	16	5.82	12	3.36
Claroteidae	60	9.49	<i>Chrysichthys filamentosus</i>	31	4.91	8	2.91	23	6.44
			<i>Chrysichthys nigrodigitatus</i>	18	2.85	9	3.27	9	2.52
			<i>Clarotes laticeps</i>	11	1.74	5	1.82	6	1.68
Cyprinidae	58	9.18	<i>Labeo coubie</i>	34	5.38	16	5.82	18	5.04
			<i>Labeo senegalensis</i>	24	3.80	12	4.36	12	3.36
Distichodontidae	48	7.59	<i>Distichodus rostratus</i>	30	4.75	14	5.09	16	4.48
			<i>Distichodus brevipinus</i>	13	2.06	4	1.45	9	2.52
			<i>Distichodus engycephalus</i>	2	0.32	1	0.36	1	0.28
			<i>Distichodus rume</i>	3	0.47	1	0.36	2	0.56
Gymnarchidae	7	1.11	<i>Gymnarchus niloticus</i>	7	1.11	2	0.73	5	1.40
Hepsetidae	3	0.47	<i>Hepsetus odoe</i>	3	0.47	1	0.36	2	0.56
Latidae	33	5.22	<i>Lates niloticus</i>	33	5.22	12	4.36	21	5.88
Mochokidae	134	21.20	<i>Synodontis batensoda</i>	35	5.54	20	7.27	15	4.20
			<i>Synodontis clarias</i>	24	3.80	10	3.64	14	3.92
			<i>Synodontis filamentus</i>	7	1.11	5	1.82	2	0.56
			<i>Synodontis membranaceus</i>	56	8.86	21	7.64	35	9.80
			<i>Synodontis vermiculata</i>	12	1.90	5	1.82	7	1.96
Mormyridae	19	3.01	<i>Mormyrus delicious</i>	1	0.16	0	0.00	1	0.28
			<i>Mormyrus rume</i>	7	1.11	3	1.09	4	1.12
			<i>Mormyrus senegalensis</i>	6	0.95	3	1.09	3	0.84
			<i>Mormyrus tapirus</i>	5	0.79	2	0.73	3	0.84
Arapaimidae	11	1.74	<i>Heterotis niloticus</i>	11	1.74	4	1.45	7	1.96
TOTAL	632	100	35	632	100	275	100	357	100

Catch per unit effort (CPUE)

The estimated catch per unit effort for nets are represented in Table 2. The results revealed that the Modified purse seine net (MPSN) had the highest mean CPUE value (3.26 ± 0.21^a) and the Non-modified purse seine net NMPSN) had the lowest mean CPUE value (1.85 ± 0.15^b). There was significant difference ($P < 0.05$) between the mean CPUE of the MPSN and the mean CPUE of the NMPSN.

Table 2: Mean CPUE of fish caught by the two purse seine nets

Net	Mean $\pm$ SE	Rank
NMPSN	1.85 ± 0.15^b	2
MPSN	3.26 ± 0.21^a	1

Means with different superscripts in the same column are significantly different ($P < 0.05$)

Key: NMPSN= Non-modified Purse seine net, MPSN = Modified Purse sein net

Discussion

The types of fish caught in this study is an indication that the fishing in Kainji Lake is multi-species. Some of the fish families caught in this study were similar to those fish families reported by Adimula and Nasiru (2005) and Ahmed and Aliyu (2006) who also worked in Kainji Lake using the mid-water sein net, Adimula (2003) in Kainji Lake and Nuhu and Yaro (2004) in Kainji Lake, while some were different. The estimated catch per unit effort mean values were higher in the Modified artisanal purse seine nets. This could be attributed to the bigger size of the net-ply, ring leads and mesh sizes used in the design and construction of the Modified purse seine nets.

Conclusion

The Modified purse seine nets caught more fishes than the Non-Modified purse seine nets in terms of number and weight of fish caught. Therefore, Modified purse seine nets had better performance than the Non-modified purse seine nets. The mean CPUE values of fish caught from the nets, was higher in the Modified purse seine nets and lower in Non-modified purse seine nets.

Recommendations

Based on the study results, the following recommendations are made:

1. The Modified purse seine nets caught more fishes than the Non-modified purse seine nets in the study area thus it is a more preferable fishing nets than the Non-modified purse seine nets.
2. The Modified purse seine net caught more of the Mochokidae family hence a suitable gear for the Mochokidae fishery of the Southern Basin of Lake Kainji.

References

- Abiodun, A. A. (1973). Waters of Lake Kainji Hydrological Predictions and Performanc. *Hydrological Sciences Journal*. 18:3, 321-327.
- Abiodun, J. A. and Ayanda, J. O. (2008). Economics of fishing gears for sustainable fish production and development in inland water bodies in Nigeria. *Continental J. of Agricultural Economics* 2: 23 –27.
- Adimula, A.B. (2003). Comparison of catch efficiency and selectivity of entangling nets: Gillnets and Trammel nets in Lake Kainji, Nigeria. *M.Tech. Thesis* submitted to the Department of Fisheries and Wildlife, Federal University of Technology Akure, Ondo State, 101p.
- Adimula, A.B. and Nasiru, M.A. (2005). The effect of hanging proportionate on catch efficiency of gill net in Lake Kainji. In: E.J. Ansa, P.E. Anyanwu, B.W. Ayonoadu, E.S. Erundu and S.N. Deekae (Eds.). *Proceedings of the 20th Annual Conference of the Fisheries Society of Nigeria (FISON)*, 14th – 18th November, Port Harcourt. Pp. 367 – 372.
- Adjarho, A.I., Dio, Z.A. and Binyotubo, T.E. (2007). Effect of net-ply on the efficiency of multifilament gillnet on Lake Kainji. *Proceedings of the Annual conference of the Fisheries Society of Nigeria (FISON)*, Akure. 26th – 28th October, 2009. Pp. 285-289

- Ahmed, Y.B and Aliyu, A. (2006). Effects of hanging ratio on the catch composition of gillnets in Jabba Lake, Nigeria. *Proceedings of the 21st Annual conference of the Fisheries Society of Nigeria (FISON)* Calabar, 13th-17th November, 2006. Pp. 325-531.
- Ahmed, Y.B., Ipinjolu, J.K. and Hassan, W.A. (2005). Catch composition of gillnets and baited longlines in the Southern basin of Lake Kainji, Nigeria. In: E.J. Ansa, P.E. Anyanwu, B.W. Ayonoadu, E.S. Erundu and S.N. Deekae (Eds.). *Proceedings of the 20th Annual Conference of the Fisheries Society of Nigeria (FISON)*, 14th – 18th November, Port Harcourt. Pp. 350 – 360.
- Binyotubo, T.E. (2011). A guide to fishing gear technology. Publication 1st edition. Remithomas Printer, Ilorin, Nigeria. 60pp.
- Binyotubo, T. E. (2016). Design characteristics and efficiency of gill nets in the Upper Nun River, Bayelsa State, Nigeria. *M.Sc. Thesis* Submitted to the Department of Fisheries and Aquatic Studies/Animal Science, Faculty of Agriculture, Niger Delta University, Wilberforce Island, Bayelsa State. 67p.
- Caruthers E., Schneider, D.C., Neilson, J.D. (2009) Caruthers Estimating the odds of survival and identifying mitigation opportunities for common by catch in pelagic gillnets fisheries. *Boil Conserv*142:2620-2630.
- Cooke, S.J. and Suski, C.D. (2005). Do we need species-specific guidelines for catch-and-release recreational angling to effectively conserve diverse fishery resources? *Biodivers Conserve*, 14:1195-1209.
- Du Feu, T. A. and Abiodun, J. A. (1998). Predictions of fish yields and the status of the Kainji Lake fishery, KLFPP *Technical Report Series No. 17*. ISBN 978-037-015-3. pp56.
- El-Zarka, E.L. (1973). Kainji Lake Nigeria. In: *Man-made Lakes. Their problems and Environmental Effects*. (Eds. W.C. Ackerman, G.F. White and E.B. Worthington). Geophysical Monographs Ser. 17: pp 197-219.
- Eayrs, S. (2005). A guide to by catch reduction in tropical shrimp – trawl fisheries. Food and Agriculture organization (FAO) of the United Nations Rome, Italy. 110p.
- Federal Department of Fisheries (2008). Fisheries Statistics of Nigeria Fourth Edition, Federal Department of Fisheries Garki, Abuja. P. 6.
- Food and Agricultural Organization, (2005) Fisheries issues: selectivity of gear. Fisheries and Aquaculture Department, Rome. Updated 27 May. Cited 28 April 2010. <http://www.fao.org/fishery/topic/12282/en>.
- Food and Agricultural Organization, (2012). Sample-based Fishery Surveys. *FAO Fishery Technical Paper*. No. 425. ISBN 92-5-104699-9. pp 144.
- Kwen, K., Davies, O.A. and Binyotubo, T.E, (2013). Survey of fishing Gear and status of fishers in Igbedi Creek, Niger Delta, Nigeria. *International Journal of Scientific Research in Knowledge (IJSRK)* 1(11): 493-501.
- Kwen, K., Kingdom, T. and Alfred-Ockiya, J.F. (2017). Effects of three fishing baits on catch composition of Drum traps in the Lower Taylor Creek Area, Bayelsa State, Nigeria. In: K. E. Lelei (Ed.). *Proceedings of the 32nd Annual Conference of the Fisheries Society of Nigeria (FISON)*, 23th – 28th, October, Anambra State. Pp. 264-267.
- Mc Curry, P. (1976) The Geology of the Precambrian to Lower Palaeozoic rocks of Northern Nigeria-a review in: C.A. Kogbe (Editor), *Geology of Nigeria*. Elizebethan Publ., Lagos. pp 15–39.
- Nuhu, M.B and Yaro, I. (2005). Selection of efficient hanging ratio of gillnet on fish catch in Lake Kainji, as means of alleviating poverty among artisanal fishermen in Nigeria. In: P.A. Araoye (Ed). *Proceedings of the 19th Annual Conference of the Fisheries Society of Nigeria (FISON)*. Ilorin, 29th–3rd December, Kwara, Nigeria Pp. 64-72.
- Obot, E. A. (1989). The macrophytic flora of the draw-down area of Lake Kainji, Nigeria. *African Journal of Ecology* 27: pp173-177.
- Olaosebikan, B.D and Raji, A. (2013). *Guide to Nigeria Freshwater Fishers*. FCFTT Publication 2nd Edition. Decency printer Ilorin Nigeria. 106p.
- Richard, L. B. Attahiru, M. S. Innocent, Y. Y. Simon, N. and Rafiu, A. (2010). Indigenous Fish Identification Methods in Lake Kainji and Jebba, Nigeria. Report and opinion, Vol. 2. Pp.6-7.
- SPSS (1999) *Statistical Package for Social Science* SPSS for windows. Release 10.01 standard versions.
- Steel, R.G.D. and Torrie, J.H. (1980). *Principles and procedures of statistics*. New York: McGraw-Hill Book Company. New York 663p.

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Capture and Marketing of Silver catfish (*Chrysichthys nigrodigitatus*) from Epe Lagoon; Problems and Prospects

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Abstract

This study examined the capture methods, and the challenges encountered in the processing and marketing benefits of *Chrysichthys nigrodigitatus* from Epe Lagoon in Lagos State of Nigeria. The study employed simple random sampling procedures for the selection of 120 respondents in three communities in Epe. Structured questionnaires were used to elicit responses. The socio-economic results showed that 89.6% of the respondents were males, and were between the ages of 41 – 50 years. Majority (93.8%) were married, 50% had formal education. Respondents had an average household size of 8 and most of the respondents (74%) practiced full time fishing. Major fish capture methods used by respondents include net (100%), hook (88.5%) and bamboo (66.4%). High income (> N400, 000) is generated from sale of fresh Silver catfish. From the study, presence of water hyacinths, inadequate transportation system, poor capital, inadequate marketing infrastructure, inadequate marketing information, instability of market prices, lack of uniform measurement, presence of marketing agents are some of the challenges fisher folks are facing, with only 17.7% of the fisher folks having access to loans and cooperative scheme. The Federal Government agencies need to improve on the drive to eradicate poverty and famine in the country by empowering the fisher folks especially in the coastal communities. The need for extension and advisory services to the fisher folks is very apt and should be intensified.

Keywords; Silver catfish, Fisher folks, Capture methods, Marketing.

Introduction

Fish is an important source of good quality protein required in human diets. It has the highest level of easily digestible protein, fats, vitamins, calcium, iron and essential amino acids when compared to other sources of animal protein such as poultry and beef (Babalola *et al.*, 2015). Artisanal fishery could be defined as the sector that employs traditional methods in operational activities which include capturing, preservation and distribution of fish and fish products (Pauly, 2006). Inland capture fisheries and aquaculture contribute over 40% to the world's reported finfish production from less than 0.01% of the total volume of water on earth (FAO, 2014a). These fisheries provide food for billions and livelihoods for millions of people worldwide. Inland fisheries are both capture fisheries and aquaculture of inland fish species for food, income, or recreation.

Marketing is the end of the production process in agriculture. It is the act of gathering in a public places for buying and selling merchandise or farm products such as fish and fish products (Asogwa *et al.*, 2019). Marketing of fish and fish products in Nigeria commences from the harvesting stage to the value chain where it gets to the final consumer (Abiodun, 2014). Farmers frequently consider marketing of fish products as one of their major challenges in fish farming. This is because while the farmers are able to identify poor prices, lack of transport, lack of ready market, and high post-harvest losses as the challenges, they are often poorly equipped to identify potential solutions (Abiodun, 2014).

Silver catfish, *Chrysichthys nigrodigitatus* is one of the most economically abundant species found in Lagos lagoon environment. *C. nigrodigitatus* (Lacépède) occur in most of the major rivers and coastal zones of Africa including Nigeria, Senegal, Gambia, Ivory Coast, Liberia, Zaire, and Gabon (Ezenwa, 1981). It makes significant contribution to the artisanal fisheries of the lagoons, 15,871 metric tonnes of *C. nigrodigitatus* were captured in 2015 (NBS, 2017-2018). The fish is caught with drag net, hook and line, bottom-set gillnet, and bottom-set traps (Bamboo and PVC pipes) because of the bottom dwelling habit. Although *C. nigrodigitatus* is a commercial important fish that is widespread in Africa tropical waters (Adite *et al.*, 2017) where they grow and spawn actively, and also constitute one of the dominant catches of capture fishery by artisanal fishermen, owing to its economic importance and suitability for culture, considerable research has been devoted to the study of several aspects of the species in Nigerian waters

(Kusemiju and Olaniyan, 1977; Ezenwa, 1981; Anyanwu, 1991). This study examined the problems and prospects of capture and marketing of *Chrysichthys nigrodigitatus* (silver catfish) in Epe Lagoon.

Materials and Methods

This study was conducted in Epe Lagoon, Lagos state, South-west Nigeria. The lagoon is a freshwater ecosystem sandwiched between two lagoons, Lekki lagoon (freshwater) in the east and Lagos lagoon (brackish) in the south with the Osun River being the main river discharging into the lagoon. Fishing is the main occupation of the people in this area. Structured questionnaires were used as an instrument to elicit information from 120 fisher folks in three communities in Epe; Ebute, Afuye and Oluwo. Ninety-six questionnaires were retrieved after the exercise and analyzed using descriptive statistics. Information was collected on socio-economic characteristics of the respondents, capture methods, income generated from Silver catfish marketing.

Results

Table 1: Socio-economic characteristics of respondents

Variable		Frequency	Percentage
Gender	Female	10	10.42
	Male	86	89.58
	Total	96	100.00
Age	30-40 years	25	26.04
	41-50 years	38	39.58
	51-60 years	23	23.96
	Above 60 years	10	10.42
	Total	96	100.00
Marital Status	Married	90	93.75
	Single	0	0.00
	Widow/Widower	0	0.00
	Separated	6	6.25
	Divorced	0	0.00
	Total	96	100.00
Level of Education	Primary Education	32	33.33
	Secondary Education	48	50.00
	Tertiary Education	6	6.25
	No formal Education	10	10.42
	Total	96	
Family Size	0	0	0
	1-4		34.38
	5-8		50.00
	9-12	5.21	5.21
	13 and Above	5	5.21
	Total	96	100.00
Fishing Status	Full time	71	73.96
	part time	25	26.04
	Total	96	100.00

Table 1, shows that, out of 96 respondents, 89.58% were found to be males while 10.42% were female. Age is an important socio-economic characteristic because it affects productivity and output. It was obtained from the survey

that 39.58% of the respondents' ages were between 41-50 years, 26.04% were between 30-40 years, 23.96% were between 51-60 years, while 10.42% were above 60 years.

A larger proportion of the fisher folks (93.75%) were married, while 6.25% were separated. This implies that majority of the fisher folks shoulder a lot of family responsibilities. Fisher folks who had formal education; secondary school accounted for 50%; 33.33% stopped after primary education, 6.25% had tertiary education, while the remaining 10.42% had no formal education. Half of the respondents (50%) had household size of 5-8 persons, 34.38% had between 1-4 persons, and 5.21% had 9-12 persons, while 5.21% had above 13 persons. This is likely to boost the availability of family labour in the sampled communities. From the survey, 73.96% of the fisher folks practice fishing as full time, while 26.04 % were on part time.

Table 2: Materials used in capturing *Chrysichthys nigrodigitatus* from Epe Lagoon and income generated from marketing

Materials		Frequency	Percentage
Net		96	100.00
Hook		85	88.54
Bamboo		67	69.79
Trap		65	67.71
PVC		12	12.50
Sales point of Silver catfish	Open market	22	22.92
	Lagoon gate	43	44.79
	Supply on request	31	32.39
	Value addition	0	0.00
Income realized in marketing of silver catfish per month	< 50,000	0	0.00
	50,001-100,000	10	10.42
	100,001-200,000	0	0.00
	200,001-300,000	16	16.67
	300,001-400,000	27	28.13
	> 400,000	43	44.79

Table 2 shows that 100% of the respondents use net to catch their fish, 88.4% use hook, and 69% use bamboo. Those who use bamboo and trap are 67% and 12.5% respectively. Majority of the respondents (44.8%) generate more than four hundred thousand naira per month. Interview with the fisher folks revealed that all of them (100%) reported challenges with water hyacinths, inaccessibility of fishing grounds as a result of vegetation invasion of fishing grounds. Water hyacinths do not allow movement of boats and sometimes spoil the outboard engines. The 42% had disturbance of large boats movement on their traps, thereby distracting the fish from their bait. About 50% of the fisher folks reported high cost of equipment as a problem, 90% reported inadequate finance and credit facilities which pose serious threat to their livelihood. Other constraints encountered by the fisher folks are lack of finance and credit facilities; majority could not afford the replacement of old outboard boat engines. This further confirms the low level of capital investment in artisanal fish production in the study area, therefore, large number of the fisher folks (52.22%) use wooden canoes.

Discussion

Most people that engaged in fish catching in Epe were still active and physically fit to paddle the canoes and set traps. The implication was that the respondents are within the productive and economic active age, and could be able to increase fish catch and improve livelihood of the families. The finding was in agreement with the report of Olaoeye (2010), who found out that most of the fisher folks are in their economic active ages to undertake strenuous task associated to the fishing enterprise. The respondents were relatively educated and this would have positive consequences on their capacity to exploit latent opportunities in the fishing activities. This finding disagreed with the assertion of Olaoeye *et al.* (2012) who reported that 60 % of fisher folks were uneducated and with the general opinion that most fisher folks are illiterates or semi illiterates, most of who dropped out of school system.

The intensity of artisanal fisheries has been found to have a direct relationship to household size (Akanni, 2010). This is also in line with the assertion of Adegbite & Oluwalana (2004), who stated that the higher the household

size, the more likelihood for labour efficiency on fisher folks. Having the majority of the fisher folks in full time fishing business shows the enterprise is a profitable one and it enables them to cater for the families. Income realized in sales of silver catfish is high because majority of the fisher folks employ negotiation to fix their fish prices. This supports the assertion by Chiwaula *et al.* (2012) who opined that when buyers bid for fish, it would result in a more rewarding pricing mechanism for fisher folks. The high marketing cost for fresh fish implies high cost in materials, besides fishing is labour intensive. The finding that most of the fisher folks sell their fish at Lagoon gate is in agreement with Achilike and Matanmi, (2014) who reported that fish farmers sell their products at farm gates in order to reduce mortality rate.

Conclusion

Inadequate transportation system, poor capital, inadequate marketing infrastructure, inadequate marketing information, instability of market prices, lack of uniform measurement, presence of marketing agents are other challenges fish farmers are facing. With only 17.7% of the fish farmers having access to loans and cooperative scheme, the Federal Government and her agencies need to improve on the drive to eradicate poverty and famine in the country by empowering the fisher folks in the coastal areas. The need for extension and advisory services to the farmers is very apt and should be intensified.

References

- Abiodun O.C. (2014). Markets and Marketing of Fish and Fishery Products in Nigeria. In: Towards ecosystem based management of fisheries: what role can economics play? Proceedings of the Seventeenth Biennial Conference of the International Institute of Fisheries Economics and Trade.
- Achilike N.M and Matanmi M.A. (2014). Women in Fish Farming. A case study of Eriwe Fish Farm Village Ijebu-Ode, Ogun State, South-West Nigeria. 28TH Annual Conference of Fisheries Society of Nigeria. 218-222.
- Adegbite D.A, Oluwalana E.O (2004). Revolving Loan Scheme as a Poverty Alleviation Strategy: A case Study of Women Groups in UNAAB Extension Villages FAMAN J., 7(2): 8-32.
- Adite A, Megnishe, H., Gbaguidi, G. A. and Ategbo, J. (2017). Reproductive Biology and Life History Patterns of the Claroteid, *Chrysichthys nigrodigitatus* (Lacépède: 1803) from a Man- made Lake in Southern Benin. *Journal of Fisheries and Aquatic Science* 12: 106-116.
- Akanni, K.A. (2010). Catch levels and capital investment of artisanal fishermen in Lagos State, Nigeria. *Turkish Journal of Fisheries and Aquatic Sciences*, 8: 361-368.
- Anyanwu P.E (1991). Influence of Salinity on Survival of Fingerlings of the Estuarine Catfish *Chrysichthys nigrodigitatus* (Lacépède). *Aquaculture* 99:157-165.
- Asogwa V.C, and Asogwa J.N (2019). Marketing of fish products. *Journal of Aquaculture & Marine Biology*. 8(2):55–61.
- Babalola D.A; O Bajimi, and S.U Isitor. (2015). Economic Potentials of Fish Marketing And Women Empowerment In Nigeria: Evidence From Ogun State. *African journal of food, agriculture, nutrition and development*. 15(2): 9922-9934.
- Chiwaula, L., Jamu, D., Chaweza, R., Nagoli, J.(2012). The Structure and margins of the Lake Chilwa -sheries in Malawi: A value chain analysis. The WorldFish Center, Penang, Malaysia. Project Report 2012-12. 34 pp
- Ezenwa B (1981). A Study of the Reproductive Biology of the Catfish, *Chrysichthys nirodigitatus* (Lacepede) in Nigeria. University of Lagos, Nigeria. Ph.D thesis.p. 178.
- FAO. (2014a). Handbook of Fishery Statistical Standards. Section G: Fishing Areas - General. Rome, Italy.
- Ifejika, P. I., Ayinde, J. O. and Sule, A. M. (2007) Socio-economic variables affecting aquaculture production practices in Borgu Local Government Area of Niger State. *Journal of Agriculture and Social Research*, 7 (2): 20-30.
- Kusemiju K, Olaniyan C.I.O. (1977). The Food and Feeding Habits of the Catfishes, *Chrysichthys walker* (Günther), *Chrysichthys nigrodigitatus* (Laceped), *Chrysichthys filamentosus* (Buolenger) in the Lekki Lagoon, Nigeria. *J. Fish Biol.*, 8: 453-458
- Olaoye O.J (2010). Dynamics of the Adoption Process of Improved Fisheries Technologies in Lagos and Ogun States Nigeria. A Ph.D thesis in the Department of Aquaculture and Fisheries Management, University of Agriculture Abeokuta, Ogun State, Nigeria.P 367.
- Olaoye, O. J., George, F. O. A., Abdul, W. O., (2012). Profitability and Viability of Fish Farming Enterprises Using Government Credit Agency Loan in Ogun State of Nigeria. *Nigerian Journal of Fisheries*, 9 (1) 460-467.
- Pauly, D. (2006) Major Trends in Small-Scale Marine Fisheries, with Emphasis on Developing Countries, and Some Implications for the Social Sciences. *Marit. Studies*, 4, 7-22.

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Effect of Bait Type on the Catch Composition of Longline Fishing In Kainji Lake

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Abstract

A 57m longline was divided into three line 19m per longline with 18 hooks on each longline the three line were baited with three different baits and were set at Monia/Taada fishing ground of Kainji Lake for six weeks. The total number of fish caught during the experimental period were 65 fishes and the weight was 3.026kg. The highest relative percentage of 64.61% was recorded by 4B Bait with a relative Species diversity index of 1. However, the dominant fishes in the catch of all the three different bait types include *Clarias anguillaris* (30.76%) followed by *Oreochromis niloticus* (18.46%) the least dominant fish was *Synodontis nigrita* and *Synodontis macrepipterus* with 3.07% each. From the result it could be seen that the natural and artificial baits are capable of catching different species of fish. However, the artificial bait performed better. This may be due to the chemical attractants of the bait (4B bait) as the odour plume was dispersed over wider area within the water body. There was significant difference ($P < 0.05$) in the number and weight of fish caught by the different baits.

Keywords: catch composition, Longline, Kainji Lake

Introduction

The longline is considered to be an environment-friendly fishing gear. It is considered to be species and size-selective, catching few non-target species, while the proportion of large fish of the target species is high (Løkkeborg and Bjørndal, 1992). It does not damage fishing grounds. It does not 'ghost fish' for any considerable time when lost in the sea. These properties make it a sensible type of gear for conservation and fisheries management purposes, combined with the fact that the catch is of good quality, because the fish is usually still alive when it is taken in. Longline fishery also has relatively low energy consumption, compared to other types of fisheries (e.g. trawling). In longline fisheries there are many factors that influence selectivity and catches, the most important are bait and hook.

In Nigeria various types of traditional fishing bait were widely used by artisanal fishermen. However the literature available showed dead document knowledge of these traditional fishing baits. The study conducted by Jibril (2004) showed the various fishing baits used by the fishermen in Kainji Lake which include cook corn bran, rice bran (in paste form) whole fish (chank/ stomach content, snail, termite/ aquatic leave. However the relative effectiveness of the bait odour for longline fishing was not adequately documented.

There has been a growing demand for bait resources seeing that standard bait types for longline fishing in Kainji Lake, such as fish, Rice bran (in paste) and corn are also used for human consumption as a result, bait prices have increased. It is therefore imperative to develop new baits that are not based on resources used for human consumption through the use of odour stimulate such knowledge would help to make longline fishing environmental friendly in the lake and the world in general. With this in mind, it is important to know the Effects of bait types on the catch efficiency of Longline fishing in Kainji Lake and to determine the catch composition of the longline baits.

Material and Method

Study Location

The study was conducted at Monai /Taada fishing village southern basin of Kainji Lake. The three different types of baits used were 4B - Flavour: Strew berry, KIFIbait – Flavour: Lemon and earth worm –flavor: Meaty.

Experimental Layout

The 57m rope was divided into three line 19m per longline with 18 hooks on each longline the three line were baited with three different baits, they, were set on the water body with the aid of canoe, a stone each was tied to each end of the rope and drop inside the water for stability, and two litres air tight Jerican were also tied to the mainline as float as well as buoy to the longline. The setting of the line was done by two (2) people, one person checking the line with

hooks while the other person was paddling the canoe. The hooks were all baited with the different (natural and artificial) baits and were set in the evening around 6:00pm and hauled the following morning by 7:00a.m to sort out the catch per baits. The trials were carried out for six weeks with three replicates.

Data collection

The fish caught by the longline were sorted out according to the different baits that caught them. The catch were taken to the workshop, sorted into their various species using revised edition of the fish guide prepared by Olaosebikan and Raji (2013). The length (Standard length and total length in cm) were measured using metric ruler and body weight of the fish was taken using portable electronic scale (Model scot pro-5pm 402) of 400g and top loader balance. The species diversity index and the test of hypothesis were done throughout the experiment period and at the end the data were pulled together and analyzed to achieve the objective of the experiment.

The Relative species diversity index (RSDI) was computed using the method of Ahmed *et al.*, (2005)

$$RSDI = \frac{\text{Number of species caught by each Longline}}{\text{Total number of species caught by all the Longline}}$$

The data obtained from the work was subjected to statistical analysis of variance (ANOVA) using the number and biomass of fish caught by the different mesh sizes and the coloured gillnets.

Results and Discussion

Catch Composition

Ten different species belonging to the five families (Cichlidae, Mochokidae, Claridae, Bargridae and Mormyridae) were caught by the different baits. The total number of fish caught during the experimental period was 65 fishes of which the highest relative percentage (64.61%) was recorded by 4B Bait. Earth worm had (35.39%) and kifi Bait had 0%. The number of fish caught by the different bait (4B Bait, earth worm and kifi Bait) were recorded starting with the 4B bait, a total number of fish caught were 42 of which *Clarias anguillaris* had the highest percentage of (35.71%) followed by *Synodontis gambiensis* had (14.28%), *Oreochromis niloticus* had (11.90%), *Synodontis ocellifer* had (9.52%) *Clarias gariepinus* had (7.4%), *Synodontis nigrita*, *Synodontis macrepipterus*, *Bagrus docmak* and *Marcusenius abadii* had (4.76%) each, finally *Lates niloticus* had (2.38%).

In earth worm bait, a total of 23 fishes were caught of which *Oreochromis niloticus* had the highest percentage of (30.45%), *Clarias anguillaris* had (21.73%) *Lates niloticus* had (13.04%), while *Synodontis gambiensis*, *Clarias gariepinus*, *Bagrus docmak* and *Marcusenius abadii* had (8.69%). However, the dominant fishes in the catch of all the three different bait types include *Clarias anguillaris* (30.76%) followed by *Oreochromis niloticus* (18.46%) the least dominant fish was *Synodontis nigrita* and *Synodontis macrepipterus* with 3.07% each.

Biomass of Fish Species Caught

A total weight of 3.062kg of fish were caught. *Clarias anguillaris*, *Synodontis gambiensis*, *Oreochromis niloticus*, *Synodontis ocellifer*, *Clarias gariepinus*, *Lates niloticus*, *Marcusenius abadii*, *Bagrus docmak*, *Synodontis nigrita* accounting for largest proportion of (21.71%), (15.41%), (9.40%), (9.11%), (6.59%), and (6.43%) respectively of the weight of all the fish caught with the different bait type. However, the 4B soap bait had highest relative percentage of (72.92%) followed by earthworm with (27.07%) while the other bait had (0%). The dominant fish in the catch of the three different baits, were recorded starting with the 4B bait a total weight of fish caught was 2233g of which *Clarias anguillaris* was dominant with (26.06%), *Synodontis gambiensis* had (16.56%) followed by *Synodontis ocellifer* had (12.89%) *Oreochromis niloticus* had (12.85%) *Clarias gariepinus* had (7.74%) *Synodontis nigrita* (7.03%) *Synodontis macrepipterus* had (5.91%) *Marcusenius abadii* had (4.34%), *Bagrus docmak* had (4.12%) and *Lates niloticus* had (2.46%). In earth worm bait, a total weight 829g of fish were caught of which *Oreochromis niloticus* was dominant with (22.31%), followed by *Lates niloticus* had (17.73%) *Synodontis gambiensis* had (13.02%) *Clarias gariepinus* had (12.78%), *Bagrus docmak* and *Marcusenius abadii* had (12.56%) and *Clarias anguillaris* had (10.01%).

Discussion

From the result it could be seen that two (4B and earth worm baits) out of the three different baits of the longline, were capable of stimulating fish to the longline thereby catching the fish this could be due to the bait odour, season, or species specific present in the Lake (Abiodun *et al.*, 2011) and reason why Kifi bait did not catch any fish might

be due to the sharp lemon odour of the bait. Comparison of the result in the quality of fish caught by different bait odour showed that the highest percentage in number and biomass of fish caught in each of the bait the B4 bait had the highest relative percentage. This may be due to the straw berry odour of the baits which is in line with Lokkeborg 2000. Who stated that the catching efficiency of baits is affected by several properties, the first one is the chemical composition with feeding attractant of the bait. Different fish species are attracted to different feeding attractant. From the result it could be seen that the natural and artificial baits are capable of catching different species of fish. However, the artificial bait performed better. This may due to the chemical attractants of the bait (4B bait) as the odour plume was dispersed over wider area within the water body. A chemical stimulus, as opposed to visual and acoustic stimuli, has two properties that are crucial for the use of bait to capture fish. First, a chemical stimulus disperses over long ranges and can be detected by fish from very long distances. For example, longlines baited with mackerel have been shown to attract cod (*Gadus morhua*) from a distance of 700 m (Løkkeborg and Bjordal, 1992).

Another behavioural study indicated that saffron cod (*Anoplopoma fimbria*) were capable of responding to odours from squid baits at a distance of several hundred metres (Løkkeborg *et al* 2010). In contrast, both visual and acoustic (except low-frequency sounds) stimuli attenuate rapidly. Second, a chemical stimulus lasts for a long period of time, whereas visual and acoustic signals fade immediately after being transmitted. Cod that responded to baits from a distance of 700 m located the baits 7 h after the longline was set, showing that bait odours last for many hours (Løkkeborg 1998). These two properties are unique to chemical stimuli, and form the basis of longlining as a stationary fishing method that has long spatial and temporal ranges.

The release rates of attractants from natural baits have been shown to decrease very rapidly (Løkkeborg *et al* 2010). It was also observed from the result that the 4B baits caught more cat fish this could be as the result of the bait odour. Because cat fish has superior sense of smelling and taste (Løkkeborg *et al*, 2010).

From the result it could be seen that the different baits are not capable of catching small and juvenile fish species and as such they are not capable of harming the fish stock and this is in line with Lokkeborg (2000) who said that longline are environmentally friendly fishing method. From the statistical analysis of variance (ANOVA) it shows there was significant difference ($P < 0.05$) in the number and weight of fish caught by the different baits.

Table 1: Summary of Number and Weight of fish caught by longline in Kainji Lake

Species	4B bait		Earth worm		Kifi bait		Total	
	No	Wt (g)	No	Wt (g)	No	Wt (g)	No	Wt (g)
<i>Oreochromis niloticus</i>	5	287	7	185	-	-	12	472
<i>Lates niloticus</i>	1	55	3	147	-	-	4	202
<i>Synodontis gambiensis</i>	2	370	-	108	-	-	2	478
<i>Synodontis fascipinna</i>	6	157	2	-	-	-	8	157
<i>Synodontis ocellifer</i>	4	288	-	-	-	-	4	288
<i>Synodontis macrepipterusu</i>	2	132	-	-	-	-	2	132
<i>Clarias anguillaris</i>	3	582	2	83	-	-	5	665
<i>Clarias gariepinus</i>	15	173	5	106	-	-	20	279
<i>Bagrus docmak</i>	2	92	2	100	-	-	4	192
<i>Marcuserus abadii</i>	2	97	2	100	-	-	4	197
Total number	42	2233	23	829	-	-	65	3062
Relative percentage	64.61%	72.92%	35.38%	27.07%				
Mean Weight Gain		53.16		36.04				47.11

Table 2: Type of fish species caught in the baited longline

Family	Species	4B soap	Earth worm	Kifi soap
CICHLIDAE	<i>Oreochromis niloticus</i>	+	+	-
	<i>Lates niloticus</i>	+	+	-
MOCHOKIDAE	<i>Synodontis gambiensis</i>	+	+	-
	<i>Synodontis nigrita</i>	+	-	-
	<i>Synodontis ocellifer</i>	+	-	-
	<i>Synodontis macrepipterus</i>	+	-	-
CLARIDAE	<i>Clarias anguillaris</i>	+	+	-
	<i>Clarias gariepinus</i>	+	+	-
BAGRIDAE	<i>Bagrus docmak</i>	+	+	-
MORMYRIDAE	<i>Marcuserus abadii</i>	+	+	-
Total No. of fish caught	10	10	7	
Species diversity		1	0.7	

Conclusion

The result from the work revealed that the different bait types except Kifi bait had effects on the catchability of the Longline but the 4B bait was more effective than other bait types.

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References

- Abiodun, J. A., Raji, A., Okaeme, A. N., & Ibeun, M. O., (ed); (2011). Fisheries statistics of Kainji Lake 1969-2009. In *Fourty years on Kainji Lake Fisheries Research*. 220-232
- Ahmed, Y. B., Ipinjolu, J.K. and Hassan, W.A. (2005). Catch composition of gillnets and baited longlines in the Southern basin of Lake Kainji, Nigeria. In: E.J. Ansa, P.E. Anyanwu, B.W. Ayanoadu, E.S. Erundu and S.N. Deekae (Eds.). *Proceedings of the 20th Annual Conference of the Fisheries Society of Nigeria (FISON)*, 14th – 18th November, Port Harcourt. Pp. 350-360
- Jubril, M.S. (2004). A survey of fishing traps and baits used in Kainji Lake. Unpublished ND project submitted to FCFFT New Bussa.
- Lokkebong, S and A Bjondal (1992). Species and size selectivity in longline fishing a Review *Fisheries Research* 13-311-322.
- Lokkebong, S. (2000). Fish behavior and gear improvement in longlining. Fishing gear system. Scottosh exhibition and conference centre, Glassgrow, Scotland.
- Løkkeborg S, Ferno A, Humborstad O.B (2010) Fish behavior in relation to longlines. In: He P (ed) *Behavior of Marine fishes: capture processes and conservation challenges*. Wiley, Oxford, pp 105–141
- Olaosebikan, B. D. and Raji, A. (2013). *Field Guide to Nigeria Freshwater Fishes*. Federal College of Freshwater Fishes Technology, New Bussa.106p.

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Blue Justice: The Bridge between Blue Economy and Small Scale Fisheries

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Abstract

Millions of women and men throughout the world rely on small-scale fishing for a living and food security. Small scale fishing contribute significantly to the local and national economies, as well as representing a wide range of value, cultural identity, and legacy in many coastal towns. Small-scale fisheries have a greater role to play in their missions to land and sea, as well as their intersection with all goals, as more pledges are made to achieve Sustainable Development Goals (SDGs). Unfortunately, in the conceptualization of the oceans as the new economic and development frontier, many development programs pushed under the Blue Growth and Blue Economy agenda tend to overlook small-scale fisheries, placing them at a disadvantage. More has to be done to promote sustainable development programs that properly support small-scale fisheries' existing and potential contributions to attaining the SDGs. Pushing for a more equitable and just space for small-scale fisheries necessitates first and foremost a grasp of the current situation, including an examination of the types of injustices and inequity that may be occurring and affecting people involving in small-scale fisheries.

Keywords: Small-Scale fishing, Fisheries, Blue Economy, Sustainable Development Goals,

Introduction

Researchers have documented environmental and social injustices caused by ocean-based advancement activities such as industrial fisheries (Jentoft, 2013; Ratner *et al.*, 2014), aquaculture (Page, 2007; Stonich *et al.*, 1997), oil and gas development (Adusah-Karikari, 2015; O'Rourke & Connolly, 2003; Watts, 2012), and blue carbon markets (Adusah-Karikari, 2015; Thomas, 2016). The idea of social justice provides valuable analytical clarity for understanding the ways or procedures by which resources and places are re-allocated, as well as the substantive objectives in terms of benefit and alms distribution to various groups of people. Furthermore, this increased focus on 'blue justice,' which we define as issues of recognition, structural, or distributive justice in the marine and coastal environment, can be seen as part of a broader critique of the reorganization of rules and authority over access to, use of, and management of coastal resources and areas of the ocean (Bavinck *et al.*, 2017; Cohen *et al.*, 2019).

International instruments that expressly reference human rights concepts have been adopted to address these long-standing challenges. The Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries, and Forests in the Context of National Food Security and the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines) are social justice-oriented instruments that call for "responsible tenure governance." Because land, fisheries, and forests are critical to achieving human rights..." and that "States should ensure that efficient fisheries management systems are in place to minimize overexploitation driven by market demand, which can jeopardize fisheries resource sustainability, food security, and nutrition." SSF Guidelines, p. 11 (Kurien, 2015). These tools are required to protect small-scale fisheries' historical and customary usage rights.

Blue Economy

The phrase "blue economy" refers to the exploitation, protection, and regeneration of the marine environment in terms of economics. The extent to which it may be interpreted differs depending on the organization. However, when defining a sustainable development approach to coastal resources, the phrase is most commonly employed in the context of international development. The blue economy, according to the World Bank (2017), is the long-term utilization of ocean resources for economic growth, improved lives, and jobs while protecting the health of the ocean environment.

Difference between Blue Economy and Blue Justice

Blue Justice is a critical approach to analyzing how blue economy and "blue growth" programs made by organizations and governments throughout the world to promote sustainable ocean development affect coastal communities and small-scale fishermen. The blue economy is intertwined with the green economy and the United Nations' Sustainable Development Goals (Isaac, 2019). Blue Justice recognizes small-scale fishing communities' rights to marine and inland resources, as well as coastal space; in some cases, these resources have been exploited by people for thousands of years. As a concept, it aims to investigate pressures on small-scale fisheries from other ocean uses promoted in blue economy and blue growth agendas, such as industrial fisheries, coastal and marine tourism, aquaculture, and energy production, and how they affect small-scale fisheries and their communities' rights and well-being.

Blue Justice

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Blue Justice is a social movement born out of the blue economy and blue growth agendas, which "frame the ocean as the new economic frontier" (Cohen *et al.*, 2019) and focus on the commodification of ocean resources through "entrepreneurship, technological innovation, multi-use offshore platforms, and new harvesting and cultivation strategies" (Cohen *et al.*, 2019). (Arbo *et al.*, 2018). It has been suggested that if the blue economy is to be truly sustainable (i.e., exist indefinitely), fisheries, particularly small-scale fisheries, should be prioritized. Small-scale fisheries have characteristics that make them more sustainable and less vulnerable to global disasters.

Blue Justice for small-scale fisheries implies including small-scale fishermen and community people as stakeholders in the blue economy agenda, with a focus on power imbalances and equality. The main concepts of social justice address who has a stake in the situation and focus on what has to be done to right past wrongs in small-scale fisheries marginalization (Jentoft, 2019).

- Restriction of access to space and resources owing to other ocean activities such as tourism, aquaculture, mining, shipping, and marine protected areas (MPAs), for example.
- Social justice is defined as an imbalance of power and relationships caused, for example, by institutions that favor certain segments of society while discriminating against others.
- Limited access to commerce and markets as a result of market certification programs or product standards created without taking into account the context of small-scale fishing.
- Exclusion from health, education, legal services, safe drinking water, and sanitation, as well as inadequate roads, transportation, and lack of access to information technology and communication linkages, are all examples of infrastructure/wellbeing justice.
- Regulations that contribute to unfair competition, such as those relating to quota allocation, gear usage control, legal status, and resource ownership, are examples of regulatory justice.
- Economic justice refers to inequitable growth possibilities caused by factors such as unjust subsidy distribution, credit restrictions, product certification programs, and limited access to land, productive assets, and livelihood alternatives.
- Procedural fairness entails limited access to decision-making processes, such as those that design without taking into account the needs of small-scale fishers.
- Environmental justice refers to the disproportionate consequences of industrial pollutants, hazards, or waste disposal on low-income and underprivileged communities, jeopardizing its members' health and well-being.
- COVID-19-related justice - disproportionate consequences of the COVID-19 pandemic on small-scale fisheries, lack of attention paid to the repercussions on small-scale fishing communities, and insufficient financing or support to alleviate the effects.

Small-scale fisheries

The nature, features, and values of small-scale fisheries are well-known. They also differ from one location to the next, making a single definition impossible to convey. Many countries define small-scale fisheries for regulatory purposes, mostly based on some measures, but other factors, such as family orientation, community embeddedness, and women's contribution, as well as the fact that some small-scale fisheries are seasonal and part of an informal economy, should be better recognized (Kurien, 2015).

Blue Justice is based on a social justice philosophy that emphasizes the importance of fairness, access, participation, and rights for small-scale fishers in the blue economy. “Critical examination of the political, economic, and ecological processes of blue economy development initiatives” is the Blue Justice method for small-scale fishing (Isaacs, 2019).

It's not simple to deal with injustices, and it's certainly not something that can be done on an individual basis. Fishermen, civil society groups, governments, environmental organizations, and academia all have a role to play in advocating for SSF Blue Justice.

- Support the implementation of the SSF Guidelines
- Illustrate small-scale fisheries as a key for sustainable ocean development, especially post Covid-19
- Include small-scale fisheries in the discussion about all SDGs
- Encourage governance reform to recognize small-scale fisheries rights and help realize their potentials
- Promote coordinated application of policies and legislation that support small-scale fisheries
- Enhance cross-sectoral collaboration and strengthen small-scale fisheries networks
- Build broad awareness about the values and importance of smallscale fisheries
- Dealing with injustices is not easy, and certainly not something that can be done at an individual level. Fishers, civil society organization, governments, environmental organizations, and academia all have a role to play in promoting Blue Justice for SSF.

Conclusion

This reviewed paper has demonstrated the gap between blue economy and small scale fisheries. Through a direct critique of past injustices, and aimed to stimulate a rigorous dialogue on how to achieve a more just and inclusive ocean economy. Hence, a commitment to ‘blue justice’ – including recognitional, procedural, and distributional concerns - need to be at the core of the blue economy agenda.

Reference

- Adusah-Karikari, A. (2015). Black gold in Ghana: Changing livelihoods for women in communities affected by oil production. *The Extractive Industries and Society*, 2(1), 24–32.
- Arbo, P., Knol, M., Linke, S., & St Martin, K. (2018). The transformation of the oceans and the future of marine social science. *Maritime Studies*, 17(3), 295-304.
- Bavinck, M., Berkes, F., Charles, A., Dias, A. C. E., Doubleday, N., Nayak, P., & Sowman, M. (2017). The impact of coastal grabbing on community conservation—a global reconnaissance. *Maritime studies*, 16(1), 1-17.
- Chuenpagdee, R. (2020). Blue justice for small-scale fisheries: What, why and how. *Blue Justice for Small-Scale Fisheries—A Global Scan*, 3.
- Cohen, P.J., Allison, E.H., Andrew, N.L., Cinner, J., Evans, L.S., Fabinyi, M., Garces, L.R., Hall, S.J., Hicks, C.C., Hughes, T.P. and Jentoft, S., 2019. Securing a just space for small-scale fisheries in the blue economy. *Frontiers in Marine Science*, 6, p.171.
- Kurien, J. (2015). Voluntary guidelines for securing sustainable small-scale fisheries in the context of food security and poverty eradication: summary.
- Isaacs, M., 2019. Is the Blue Justice concept a human rights agenda?.
- Jentoft, S. (2013). Social justice in the context of fisheries—a governability challenge. In *Governability of Fisheries and Aquaculture* (pp. 45-65). Springer, Dordrecht.
- Jentoft, S. (2019). Life above Water: Essays on Human Experiences of Small-Scale Fisheries; TBTI Global: St. John's, NL, Canada.
- O'Rourke, D., & Connolly, S. (2003). Just oil? The distribution of environmental and social impacts of oil production and consumption. *Annual Review of Environment and Resources*, 28(1), 587-617.
- Page, J. (2007). Salmon farming in First Nations' territories: A case of environmental injustice on Canada's West Coast. *Local Environment*, 12(6), 613-626.

- Pauly, D. (2018). A vision for marine fisheries in a global blue economy. *Marine Policy*, 87, 371-374.
- Ratner, B. D., Åsgård, B., & Allison, E. H. (2014). Fishing for justice: Human rights, development, and fisheries sector reform. *Global Environmental Change*, 27, 120-130.
- Stonich, S. C., Bort, J. R., & Ovaras, L. L. (1997). Globalization of shrimp mariculture: the impact on social justice and environmental quality in Central America. *Society & Natural Resources*, 10(2), 161-179.
- Thomas, S. (2016). Between Tun Mustapha and the deep blue sea: the political ecology of blue carbon in Sabah. *Environmental Science & Policy*, 55, 20-35.
- Watts, M. J. (2012). A tale of two gulfs: life, death, and dispossession along two oil frontiers. *American Quarterly*, 64(3), 437-467.
- World Bank, & United Nations Department of Economic and Social Affairs. (2017). *The potential of the blue economy: increasing long-term benefits of the sustainable use of marine resources for small island developing states and coastal least developed countries*. World Bank.

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Performance Evaluation of Conventional Malian Trap and Modified Variants on Lake Kainji, Nigeria

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Abstract

Lake Kainji is the most prominent man-made lake in Nigeria, and it has given great impetus to the development of fisheries resources in the country. Malian trap (Gura) is currently most preferred in Lake Kainji, but lack of escape vents limits its international acceptance and profitability respectively. Hence this study was initiated. The conventional Malian Trap (ConM) and six variants of modified Malian traps (MM) were constructed. Modifications were via provision of escape vent (20, 40 and 60mm gap) and location of the valve (0 and 50 % height). These were set at the littoral, limnetic and profundal zones of each of the six stations of the Lake. Catch of each of the set CT and MT at each of the zones of the stations were assessed for catch 48hr after setting (soak time). Fishing trials was carried out for 12months covering both wet and dry season. The study highlighted information on the catch efficiency, pattern and trend of catch in both wet and dry season.. Trap unlike other gear harvest live fish with return of undersized fishes subjected to the fishermen prerogative, from this study it can be therefore concluded that inclusion of escape gap in Malian trap fisheries is a necessity to regulate growth overfishing and ensure sustainable fisheries.

Keywords: Fishing gear technology, Malian trap, fishing gear modification, LIFE gears

Introduction

Fish traps are an effective and economically important multi-species fishing gear used widely for harvesting crustaceans and finfish around the world (Recksiek *et al.*, 1991) Trap catch is affected by numerous factors including water temperature, water quality, forage and feeding regime, population density, and size structure, weather patterns, and the moon phase, trap design, trap density, number of trapping days, trapping strategy, and bait type and bait quantity (Romaine, 1995). Whereas trawls and longlines may be difficult to operate on some fishing grounds, demersal traps can be the predominant gear used in such habitats. Furthermore, the increased concern on the impacts of towed gears on seabed habitats has also highlighted the potential benefits of non-towed fishing gears. Therefore, there has been increased research by fisheries scientists on the catch rates of fish traps in recent years (Mustafa *et al.*, 2005). Fish traps have a low impact on the environment and are essential in the mitigation of the collapse of many fisheries, but they may require periodic adjustment for sustainable selectivity. The Malian trap (locally known as gura) categorized as low impact and fuel-efficient (Life) gears are essential in sustainable fishing of lake fisheries (Suuronen *et al.*, 2012). Malian traps are one of the commonest Life gear and are being preferred in lake fishing (Oyebola and Ogunfowora 2015), but there is a dearth of information on recent modifications of the trap for improved selectivity. Many research works (Ago *et al.*, 2012. Ogunfowora *et al.*, 2011) have been done with regards to most of the life gears, but there seems to be a dearth of information concerning the traps especially the Malian trap. Many of the available published studies (Reed *et al.*, 1967; Holden and Reed, 1972), (Udolisae *et al.*, 1994, and Umar and Ipinjolu (2001) were simply descriptive. Du Feu and Abiodun (1999), Agbeleget *et al.*, (2004) have recommended the use of more durable material for the construction of Gura trap. Therefore there is an urgent need to review not just the mesh sizes of net used in a trap but also the introduction of escape gaps into it in consonance with international best practice which mandates the release of undersized catches by the introduction of a mechanism that allows the escape of this fishes without interference from fishermen who often in the developing nation have a complete disregard for retention and release of matured or undersized catches. Hence the need to carry out a study on the effect of escape gap introduction to the catch efficiency of the Malian trap.

Materials and Method

Trap description/ specification

The gura traps used for this fishing trials were made from lianas and nylon netting materials with the following specifications: Mesh-size- 1.0cm, Total height-100cm (1m) base diameter- 80.0cm, Non-return valve- 10.0cm, top opening-30cm. Three non-Return valves are made of strong netting materials which allows a varied array of fish to be caught. The trap top has a loose hanging net that could be open for catch retrieval and bait placement. Similar specifications were reported by Ogunfowora et al (2011).For the modified trap adjustment were made to the positioning of the valve entrances and inclusion of the escapes gap (plate1) with diameter of 20mm, 40mm and 60mm respectively (Table1).



Plate1: Modified Malian trap with an arrow indicating escape gap position

Table 1: Design characteristics and specification of the conventional Malian trap and the six variants

Name of trap	Trap length (cm)	trap width/ diameter (cm)	mesh size (mm)	valve length (cm)	valve width (cm)	position of valve	no of valves	netting material	escape gap
Conventional Malian trap	100cm	80cm	10mm	10cm	15cm	base	3	Synthetic fiber	absent
Modified Malian trap1	100cm	80cm	10mm	10cm	15cm	base	3	Synthetic fiber	Present20mm
Modified Malian trap 2	100cm	80cm	10mm	10cm	15cm	base	3	Synthetic fiber	Present 40mm
Modified Malian trap 3	100cm	80cm	10mm	10cm	15cm	base	3	Synthetic fiber	Present 60mm
Modified Malian trap 4	100cm	80cm	10mm	10cm	15cm	midpoint	3	Synthetic fiber	Present 20mm
Modified Malian trap 5	100cm	80cm	10mm	10cm	15cm	midpoint	3	Synthetic fiber	Present 40mm
Modified Malian trap 6	100cm	80cm	10mm	10cm	15cm	midpoint	3	Synthetic fiber	Present 60mm

The escape gaps used in the study were obtained from old tube trimmings (plate2) and attached to the base of the modified variants of the Malian trap (Plate3)



Plate2 : Escape gaps derived from rubber tube trimmings	Plate3 :Escape gaps Installment

Plate2: Escape gaps derived from rubber tube trimmingsPlate3: Escape gaps Instalment

Trap setting and Catch retrieval

A total of 84 Traps were used in the performance evaluation study comprisingof the conventional Malian trap and the six variants set in a chain of 7 and duplicated in both shallow and deep water across the six sampling stations chosen. Each set of Trapswere deployed at same depth in each sampling location and Corn offal was used as a reference bait during the gear trials. A spacing of 10 m was allocated to each set of trap to inhibit potentials leading from one bait to the next in each sampling stationanda set and retrieval period of 48hours was used during each fishing trials before collection, rebaiting, and re-randomizing the order of traps along in a set.

Result and discussion

Based on the result in (Table 1 and Table 2) weight of the fish recorded in both dry and wet season were higher in the conventional Malian trap and the modified Malian trap (MM1) with the smallest escape gap of (20mm), an indicator that the only a tiny fragment of the catch are allowed to be filtered out. The same pattern was observed in the specie distribution in (Table 3) with majority of the specie caught also having the highest occurrence in the conventional and Modified Malian trap 1, the conventional Malian trap catch rate can be attributed to the total disregard for size selection as all the caught fish are harvested. However as the escape gap sizes increase so also is the weight of fish caught decreasing which is a clear inference of growth over fishing in most of the sampling site this agrees with the assertion of Abiodun J.A 2003 and Yem, I.Y, *et., al* (2007) of depletion of commercially important freshwater fish species such as Lates niloticus, Bagrus spp., and Cichlids which are wantonly removed by fish folks from water regardless of their sizes.

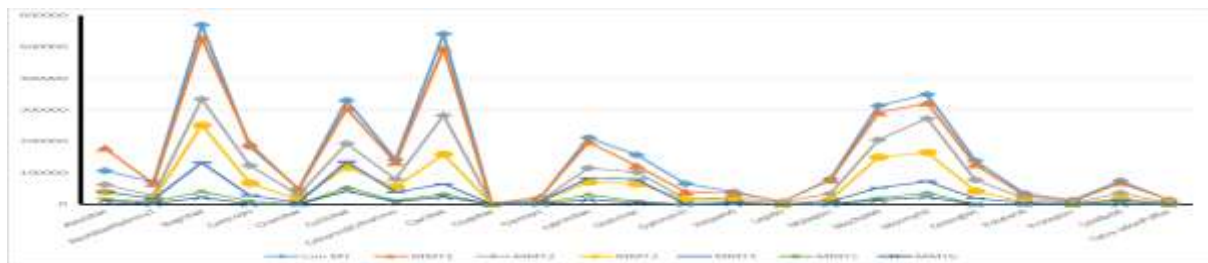


Table1: Dry Season weight of fish caught by gear types

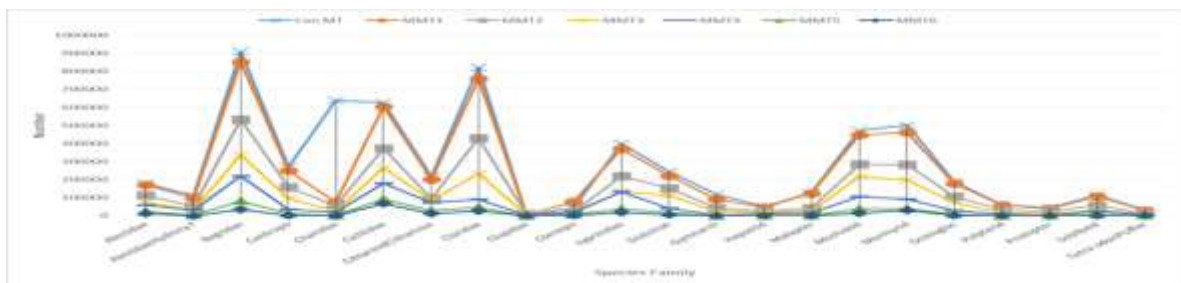


Table 2: Wet Season weight of fish caught by gear types

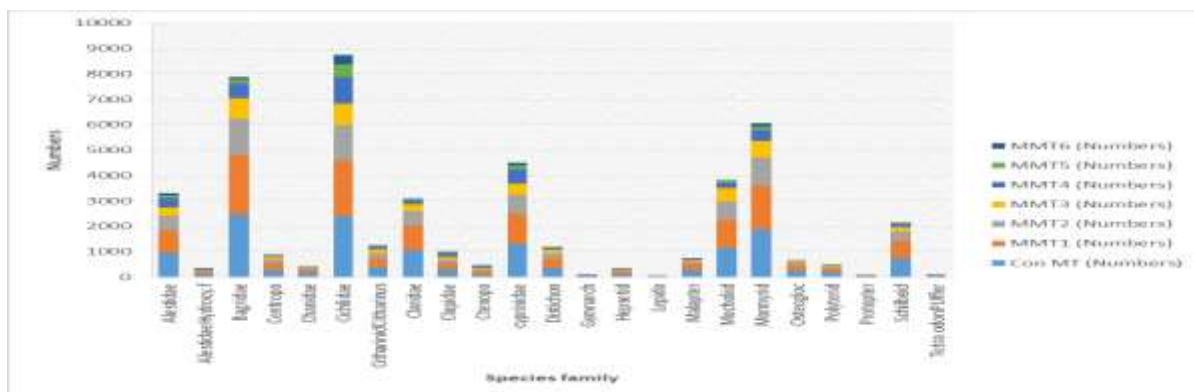


Table 3: Species distribution by gear type

Conclusion and recommendation

The catch rate of the modified Malian trap 1(MM1) in comparison to the conventional Malian trap is very encouraging despite the inclusion of the escape gap and is a clear evidence that sustainable fisheries can still be achieved while maintaining the ecosystem without growth overfishing. It is therefore recommended that escape gaps should be mandatory and included in all the state and federal fishing edicts for fishing traps as a way of mitigating against catches of undersized fishes which hitherto were only monitored through mesh size regulation.

Acknowledgment

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References

- Abiodun, J A (2003) Evaluation of Fisheries Catch Trend on Lake Kainji, in Nigeria, 1995-2001. *Journal of Applied Sciences & Environmental Management*, Vol. 7, No. 2, Dec, 2003, pp. 9-13
- Ago, N.D., Balogun, J.K, Auta J., and Ogunfowora O.O (2012). Comparative performance of a newly developed fish trap and the Malian trap in Kainji Lake, Nigeria. *ARPN Journal of Agriculture and Biological Science*.7(6):474-483.
- Du Feu, T. A., and Abiodun, J. A. (1999). Fisheries statistics of Kainji Lake, Northern Nigeria. New-bussa: Kainji Lake fisheries promotion Project/GTZ.
- Holden, M. and Reed, W. (1972). West African freshwater Fish – West African Nature Handbook, Longman, London, 68pp.
- Ipinjolu, J. K., Agbelele, O. O., and Hassan, W. A. (2004). An exploratory survey of Malian and ndurutu traps in river Rima northern western Nigeria. Fison. Ilorin: Fisheries Society of Nigeria.
- Ogunfowora, O.O., Yem, I.Y., and Ogunfowora, S.A., (2011). The performance of Malian trap using four bait types in Lake Kainji, Nigeria. *Continental Journal of Fisheries and Aquatic Science* 5(3):6-13
- Olaosebikan B.D and Raji, A. (2013). Field Guide to Nigerian Freshwater Fishes. Revised edition 144pp.
- Oyebola O.O and Ogunfowora O.O (2015) Challenges to effective fishing and preferred fishing gear in a hydrodynamic freshwater system, *Continental Journal Biological Sciences* 8(1); 24-33, 2015
- Reed, W., Burchard, J., Hopson, A.J., Jennes, J and Yaro, I (1967). Fish and fishes of Northern Nigeria. Ministry of Agriculture, Northern Nigeria, Gaskiya, Zaria. 226pp
- Recksiek, C.W., Appeldoorn, R.S., and Turingan, R.G., 1991. Studies of fish traps as stock assessment devices on a shallow reef in south-western Puerto Rico. *Fish. Res.* 10, 177-197.
- Romaire, R.P. 1995. Harvesting Methods and Strategies used in Commercial Procambarid Crawfish Aquaculture. *Journal of Shellfish Research*, 14(2): 545-551.
- .Stoner, A. W. (2004). Effects of environmental variables on fish feeding ecology: implications for the performance of baited fishing gear and stock assessment. *Journal of Fish Biology*, 1445–1471.
- Suuronen, P., Chopin, F., Glass, C., Løkkeborg, S., Matsushita, Y., Queirolo, D., and Rihan, D.2012. Low impact and fuel-efficient fishing—looking beyond the horizon. *Fisheries Research*, 119–120: 135–146
- Umar, K. A., and Ipinjolu, J. K. (2001). The efficiency of baited Malian and Ndurutu trap in three freshwater bodies. *Journal of Agriculture and Environment*, 101-111.

Yem, I.Y, Sani, A.O. Bankole, N.O. Onimisi, H.U. and Musa, Y.M.(2007) Over fishing as a factor responsible for declined in fish species diversity of Kainji, Nigeria. 21st Annual Conference of the Fisheries Society of Nigeria (FISON) Calabar, Nigeria. pp79-85

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Identification of Major Fishing Gears and Crafts in Omambala River and Niger River (Ogbaru Axis), Anambra State

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Abstract

This work was conducted to identify major fishing gears and crafts that were used by artisanal fishermen in two fishing communities in Anambra state namely; Omambala (Otuocha) and Ogbaru (River Niger Axis). The study was carried out between February, 2021 to August, 2021. Primary data were collected from local fishermen through Personal Interview (PI), secondary data were collected from the measurement of the fishing gears and craft. The study reveals different types of fishing gears including gill nets, cast net, lift nets. The mesh size of the cast nets varies in 2.5-3.5 mm; gill nets vary in 12.7-30.48 mm. Generally, these nets were lasting for up to 2-3 years. For gears preservation no chemical or medicine were used, only that the nets were dried under the sun and put up on a safe and dry place. Four types of fishing crafts were recorded from the study which included planked canoe, dugout canoe, fiber-glass canoe and metal canoe. Traditionally, Oji (*Milicia excels*), were used in boat making which were locally available and lasts longer for 5-10 years. Planked canoe was identified as the dominant fishing craft (72% and 56%) in both Omambala and Niger river (Ogbaru Axis) each as well as gill nets (44% and 45%) in both water bodies.

Keywords: Omambala, Ogbaru, fishing craft and gear.

Introduction

Fishing is an act of harvesting fish , and equipment or devices used for fishing are called “fishing gears. Fishing gear can be described as any kind of equipment used in harvesting, cropping or capturing fish from any water body. Fishing gears are the tool or implement or equipment used in capturing fish from any water body such as traps, hooks and lines, gill nets, trawls, seine nets, lift nets, clap nets, spears, cast nets, entangling nets, drift nets etc. (Nuhu and Yaro, 2005; Tagago *et al.*, 2011; Davies and Kwen, 2012) while fishing method is how the gear is used. According to FAO (2011) out of 1.9 million people engaged in fishing, about 98% belongs to the artisanal sector. However, this sector is characterized with low technology, lack of modern equipment and low fund resulting in labor intensiveness with little or no opportunities to expand. Fish is the cheapest source of animal protein to human, therefore there is need to protect and manage the fishery. In order to do this effectively, detail knowledge of the gears and crafts is needed. Due to the varied habits and habitats of the fish species peculiar to water bodies, assorted array of fishing gears are equally employed to catch them.

Several studies have surveyed the fishing gears and crafts in Nigeria inland water (Ohaturuonye *et al.*, 2015) Alegbelege who studied gear and crafts of Oguta Lake. (Ambrose *et al.*, 2001; Alegbelege *et al.*, 2003; Du Feu, 2003; Emmanuel, 2009; Kingdom and Kwen, 2009; Yisa *et al.*, 2008). Few studies have focused on the fishing gears in Kainji Lake (Yisa *et al.*, 2008; du Feu and kasali, 2003; du Feu *et al.*, 2007; NIFFR, 2002), and the last study is already more than 10 years old. But, ultimately the choice of fishing gear relates to the fish stock (resources), fishing communities and socio economic characteristics of the fishers. However, no work has dealt with the different types of fishing craft and gear in the two rivers under study.

Material and Method

Study area

The study was carried out in a fishing community Omambala (Otuocha) and Niger river (Ogbaru Axis). Omambala (Otuocha) is a town and Headquarters of Anambra East Local Government Area of Anambra state, Nigeria. Otuocha River is found in Umuleri and is a major Umuobanam clan. The name “Otuocha” emanated from the “Oche coasts “called “Otu Oche” owned by the “Amuka –Adege Exogamous village of Ikenga Umueri”.

Otuocha River is located on the map along the latitude 6°33'33"N and longitude 6°85'12"E. it is a tributary of River Niger, on the North East by Emu stream, South East by Ezu River and South West by Akor River.

The entire Ogbaru Local Government Area which constitutes a large wetland zone is located in the South Western part of Anambra State, and lies between latitudes 5°42' and 6°08'N and Longitudes 6°42' and 6°50'E. It is bound in the North by Onitsha South Local Government Area, in the East by Idemili South, Ekwusigo and Ihiala Local Government Areas, in the West by Delta State and in the South by Rivers and Imo States.

Data Collection

Frame and Catch Assessment Survey was used to collect data. These are standardized survey methods, which include stratification and classification. Stratification refers to areas that were covered, which include choosing the landing sites of the water bodies for data collection. This was done to cover the whole stretch of the water bodies as high fishing activities around these areas were also considered. Landing sites was visited on regular basis for a period of six months for data collection.

The rivers were divided into landing sites (station 1, 2, 3.) Classification method was used to ascertain or identify the kind of crafts and gears that was found at each of these water bodies, following the methods of FAO (2011). The various fishing gears and crafts of each of these water bodies were categorized according to types. Photographs of gears, crafts were taken and the dimensions (width, length, depth) recorded. 50 Fishermen were interviewed on the traditional gears they use and questioned about the local names.

Data Analysis

The data collected from this study was Analyzed using statistical measures of dispersion (percentage, mean, mode and standard deviation) to determine the dominant Fishing Gears and Crafts in each area.

Results

Table 1: Percentage of Fishing Crafts in Omambala and Ogbaru

Name of Gear	Number	Percentage
OMAMBALA		
Gill Net	50	44
Cast net	30	27
Malian trap	18	16
Lift net	15	13
OGBARU		
Gill net	40	45
Cast net	29	33
Malian trap	20	22

Table 2: Percentage of Fishing Gear in Omambala and Ogbaru.

Name of craft	Number	Percentage
OMAMBALA	Number	Percentage
Planked Canoe	23	72
Metal Canoe	2	6
Dug-Out Canoe	7	22
OGBARU		
Planked Canoe	20	56
Dug-Out Canoe	6	16
Fiber glass Canoe	10	28

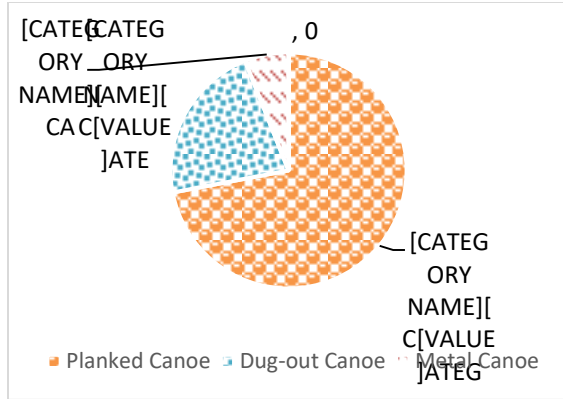


Figure1: Pie chart indicating percentage of fishing craft in Omambala

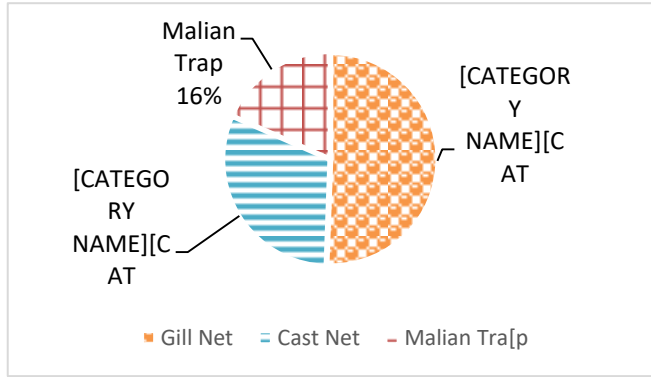


Figure 3: Pie chart indicating percentage of fishing Gear in Omambala

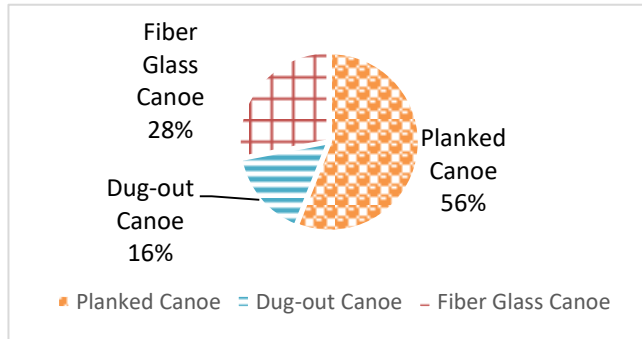


Figure 2: Pie chart indicating percentage of fishing craft in Ogbaru

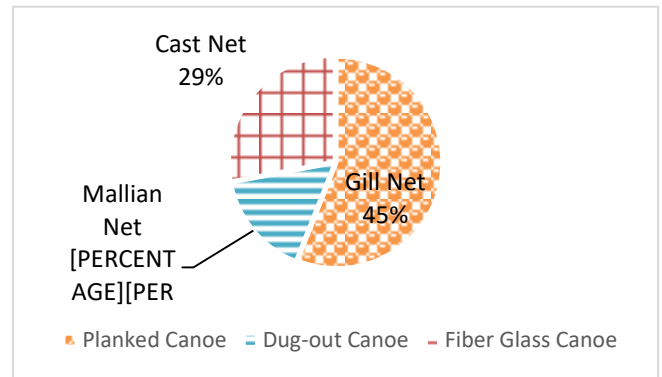


Figure 4: Pie chart indicating percentage of fishing Gear in Ogbaru

Discussion

The result of the fishing crafts found in Omambala and Niger river (Ogbaru Axis) River shows that planked canoe (72%) was the most dominant craft used by fishermen in Omambala while dug-out canoe and metal canoe were (6 % and 22 %) in the same water. Also for Ogbaru the abundance of fishing craft was in this order 56 %,28 %,16 %; planked canoe > fiber glass canoe >dug-out canoe respectively.

The result of the percentage of fishing crafts found in Omambala and Ogbaru River as presented in table 1, it shows that majority of the fishermen used planked canoe (72%) while only few made use of Dug-out (22%) canoe and metal canoe (6%) respectively. Also for Ogabru River (56 %) of planked canoe was recorded, (16 %) of dug-out canoe while finger glass canoe was (28 %) this finding is different from the finding of Ohaturuonye *et al.*, (2015) who opined that one man dug-out canoe was the most abundant fishing craft in Oguta lake. The result of the fishing gears found in Omambala and Ogbaru River shows that gillnet (44 % and 45 %) was the most dominant gear used by fishermen in both water bodies, followed by cast net (27 % and 33%) while Malian trap (16 % and 22%) , while lift net (13%). was only identified in Omambala.

Conclusion

The present study revealed arrays of fishing gears in use (Gill net, Malian trap, cast net and Lift net) and crafts (planked canoe, dugout canoe, fiber glass canoe and metal canoe) in the two water bodies in Anambra State South Eastern Nigeria. Gill net was the most dominant gear while lift net was the least. For fishing craft, planked canoe was the most used in the area while fiber glass and metal canoe were least in the two rivers. Traditional fishing gears and crafts are still in use. Gillnets, cast nest, malian trap and lift net as fishing gears, and plank canoe,dug – out

canoe and metal canoe as fishing crafts respectively were commonly used. High cost of outboard engine contributed to low or non-usage in the study area.

References

- Alegbeleye, O. O, A.RAji and M.M.Mofio. (2003).Fishing Gear Survey of Lake Chad.*In*:A.A Eyo and A.Ajad (Eds).*Proceeding of the 16th Annual Conference of the Fisheries Society of Nigeria* (FISON).pp:87-98
- Ambrose EE, Udolisa REK, Solarin BB, Lebo PE. (2001). Technological status and development prospects of small scale fishing crafts in Nigerian Coastal Water. *Proceedings of the 14th Annual Conference of the Fisheries Society of Nigerian (FISON) held at Ibadan, 19th–23rd January, 2001*;140–145.
- Davies O.A., Kwen K., (2012). Fish assemblages of selected traditional fishing traps (Malian and Ikara) in the Upper Nun River, Niger Delta, Nigeria, *FS J. Res. Basic and App. Sci.*, 1(2): pp 8- 11.
- Du Feu, T. A. and Kasali, A. (2015). Fishing gear survey, Kainji Lake, Nigeria. Tech. Rep. Ser. du Feu, T. A. (2003). Tropical Reservoir Fisheries; Lake Kainji, Nigeria - a case study. Ph.D. Thesis. University of Hull. pp334.
- Emmanuel, B. E. (2009). Fishing crafts characteristics and preservation techniques in Lekki lagoon, Nigeria. *Journal of American Science*; 6 (1): pp 105-110.
- Food and Agricultural Organization, (2011). FAO year book fisheries statistic catches and landing 2009, fisheries series 36 and FAO Statistic series 68. Rome, FAO
- Kindom,T., and Kwem.L. (2009). Survey of Fishing Gear and methods in the lower Taylor Creek Area.Bayelsa State Nigeria. *World Journal of Fish and Marine Sciences*1 (4):313-319
- National institute for freshwater fisheries Research (NIFFR), 2002. National surveys of fishing gears And crafts on Nigerian inland water bodies. NIFFR occasional paper No.4.ix, pp 4. ISSN 07942451, ISBN 978177-051-1.
- Nuhu,M.B and I.Yaro.(2005).Selection of efficient hanging ratio of gill net on fish catch in Lake Kainji as a eans of alleviating poverty among artisanal fisherman in Nigeria.*In*:P.A.Araoye(eds).*Proceedings of the 19th Annual Conference to Tropical Fisheries Society of Nigeria(FISON)*.pp:64-72
- Ohaturuonye, S.O., Osongwu, L.E and Nwaka, S.U. (2015). Prelimnary study of fishing gears and crafts in Oguta Lake fishery. *Procedings of the 30th FISON Annual Conference*, pp, 22-27
- Tagago TA, Ahmed YB (2011). Fishing gear survey of Tatabu floodplain, In: R.J. Koko and A.M. Oire (Eds), *Proceedings of the 26th Annual Conference of the Fisheries Society of Nigeria (FISON)*. 28th November- 2nd December, Minna, Niger State, Nigeria, pp. 109-116.
- Yisa, Z. Apeloko, F. and Kasali, A. (2008).Fishing gear survey of Kainji Lake, Nigeria, West Africa. NGKLFPP Tech. rep. Ser. pp 7.

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Gill Net Selectivity and Stock Assessment of Kugbo Creek in the Delta Region of River Niger, Nigeria

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Abstract

Gill net selectivity and stock assessment studies was carried out in Kugbo Creek, in the Delta region of River Niger, Nigeria. Nine gill nets of varying sizes ($\frac{3}{4}$ ", 1", 1½", 1¾", 2", 2½", 3½", 4" and 7") were used at 7 hours-day active fishing. Mean biomass of 2,054kg represented the mean total daily catch of 2,243 individuals. Highest mean catch per net was observed in mesh size 2½" with a total mean catch of 653 individuals or 981.31kg biomass that represented 47.78% of the total daily catch. Lowest catch was with 7" mesh, 21 individuals or 130kg biomass per day representing 6.33%. The analytical method of the age composition of catch in the fisheries stock assessment showed there few old fishes in the fisheries which depict over fishing pressure, which here may have resulted from loss due to pollution. Generally, biomass decreased with decreasing fishing net mesh and increases with increasing mesh sizes.

Keywords: Fishing gears, Catch efficiency, Net selectivity, Riverine communities, Niger Delta.

Introduction

In Nigeria, fishing constitutes 18 to 24% of the country's agricultural produce (The Federal Government of Nigeria, 1992). The practice of fishing is as old as the culture of the people of the riverine communities in the Niger Delta. Fishing gears of cast nets, gill nets, seine nets, impounding nets and assorted traps (including the earthen pond trap) are commonly used in this artisanal fisheries industry and most Nigerian waters probably due to catch efficiency (Fabrizio, *et al.*, (2015); Ufodike *et al.*, 1989) and affordable cost. To increase efficiency, Hinz *et al.*, (2012), Stewart *et al.*, (2010) and Stainberg (1964) have recommended transparent monofilament nets in clear waters. However, this has its disadvantage. Monofilament plastic nets are not environmentally friendly as it is non degradable. If carelessly left in the water without proper disposal, it continues to kill fish that entangled with it. The choice of fishing gears in a fishery depends on the target species behaviour and the fishery characteristics. That is, whether species are pelagic or demersal, economic value, depth of water, fishing depth and characteristics of the bottom (as gears are set in contact with bottom) and the physiognomy.

Materials and Method

Location of study area was as described in Edoghotu, *et al.* (2016). The study involves experimental fishing, observation, enumeration, identification and classification fish samples, establishing gill net selectivity and stock assessment. Sampling was carried out in all 3 aquatic zones differentiated by salinity and vegetation type. Nine varying sizes of gill net of $\frac{3}{4}$ ", 1", 1½", 1¾", 2", 2½", 3½", 4" and 7" stretched mesh were employed. Each net was 40m long and 3m wide, the surface area for each net was 120m² while fleet area was 540m². Catch from each zone were separately kept and transported in cool boxes to the laboratory for proper identification, classification and analysis.

Total number, weight and total length of each species caught were recorded. Weighing of the fish was done with electronic sensitive weighing balance (model scout pro 601) with 1-600g measuring capacity, for fish with relatively small weight, while those with weight larger than 600g were weighed with model HANA commercial weighing balance. Fish weights were determined after draining water from buccal cavity and blot – drying the samples. Sampling was done by – weekly for 24 months' period while the regime for each day was 6 hours.

In each of the 3 aquatic zones sampled, 3 sites (stations) were established for the purpose of the experimental fishing. The major fisher communities within the zones are Amorokeni, Amuruto and Emago, Ebililagh communities (Edoghotu, *et al.*, 2016). Identification of fish specimens was according to the descriptions contained in Idodo – Ume (2003), Reed (1967) and FAO (1990). Seasonal variation, abundance and frequency of occurrence

were established for the three zones sampled. Fish age were determined with Von Bertalanffy Growth Model (VBGM) for stock assessment.

Results

Results of the study are presented in tables 1 - 8. It was observed that there was decline of fish assemblage with the various gill nets in both number and biomass, especially in large mesh sizes of 4" and 7" (Table 1) and small mesh sizes of ¾", 1", 1½" and 1¾". Highest biomass (981.31kg) of fish caught per mesh size was recorded in 2½" mesh size. Its catch represented 47.79% of the total biomass. This was followed by mesh size 3½" with biomass of 337.06, representing 16.41% of the total biomass. Least biomass (0.9kg) was with mesh size ¾" representing 0.04% of the total biomass. The result further revealed that mesh size 2½" and 3½" were the most efficient accounting for 64.19% of the total biomass, while the rest accounted for 35.89%. However, the number of fish caught per mesh size was highest with mesh size 1¾" having daily mean count of 815 individuals that represents 36.34% of total number caught during the period. This was followed by mesh size 2½" with 653 individuals that represented 29.11% of the total catch. Least number of fish caught (21 individuals) was with mesh size 7", represented 0.94% of the total fish caught. Monthly mean catch was highest in February with 489 individuals that represented 21.70% of the total catch. This was followed by March with 266 individuals representing 11.81% of the total catch. Least was September with 74 individuals or 3.28% of the total catch.

Similarly, monthly biomass was highest in November with 5,241.83kg with 71.77% of the total biomass. Next was in December with 1,226.1kg representing 11% of total biomass. Least monthly biomass was 169.31kg in the month of September, representing 3.34% of the total.

However, the distribution of the three zones sampled showed that the brackish water zone was highest with 876.71kg or 25.71% of the total biomass. Number of fish caught per zone increased from fresh water to the brackish water zone. Stock assessment of the fisheries further revealed the largest individual fish landed during the study as *Gymnarchus niloticus*, a fresh water species with total length and weight of 117cm and 4,484.4g respectively. This was followed by another fresh water species, *Heterotis niloticus* (87cm and 4,524g) and *Papyrocranus afar* (40cm and 691.6g), while the largest of the brackish water was *Chrysichthys nigrodigitatus* (59.8cm and 2,601.1g). The smallest fish recorded in the fresh water zone was *Polycentropus sisabrivata* that was 3.68cm in length and 27.9g weight, while in the brackish zone was *Syngnathus* with 8.4cm length and 4.8g weight respectively.

Catch per unit effort was highest in the month of November with mean daily catch of 37 individuals per hour. It was lowest in September with a mean daily catch of 7 individuals per hour. Catch per unit biomass had the highest (20.2kg/hour) in the month of November. Lowest value (0.9kg/hour) was in the month of February. Stock mean total was 14.2kg/hr. Estimated catch biomass and potential yield biomass during the period of this study was 2,054kg, and gave an average daily production of 2.1 metric ton/km². Total catch landed in number was 2,243 individuals. This gave an annual mean daily production estimate of 187 fish and a standing stock of 5 individuals per km².

Discussion

The small mesh sized gill nets of 2½" to 3½" were the most commonly used nets in this artisanal fisheries and may be due to their efficiency. The decline in fish number caught with increasing and decreasing mesh size of 4" and 7" was a reflection of the reduction in stock size which increased with age of individual fish caught. However, the result showed that gill nets of mesh size 1¾", 2", 2½" and 3½" were the most efficient fishing gill nets constituting daily catch of 36.3%, 24.9%, 29.11% and 9.1% respectively, of the total fish catch. This was in agreement with the findings of Fanbrizio et al (2015) and Abowei (2000) in the River Nun and is in accordance with the recommendations on the use of 2½" mesh of Ita and Machili (1997) and Bankole (1990) for artisanal fishing due to efficiency. Least fish biomass were with mesh size 4" and 7" while sizes 1¾" to 3½" had the highest. The maximum of 981.3kg was observed with mesh 2½" representing 47.8% of the total biomass and gill net size 1¾" to 3½" were most efficient with percentage catch of 10%, 13.4%, 47.8% and 16.4% of total biomass respectively. The smaller mesh sizes of ¾" to 1½" did not have much catch since they were designed for small fishes which are predominantly fries and fingerlings in nurseries or taking shelter in less disturbed areas with little or no predation such as the fresh water grass mat, mangrove and fresh water swamps. Thus are not yet recruited in the available cohort. Similarly, the large mesh size of 4" and 7" did not have much catch because most of the fish population easily escape from the escape from such coarse mesh. Also, the population of the cohort for this mesh size is sparsely populated as most of the members are out of the fisheries either through natural or fishing mortality.

Stock sizes estimated from the gill nets were highest in November and lowest in the month of September. This was attributed to seceding flood associated with this month and the end of August break respectively. Since all through the year migration into swamps and back to the main creek, from the fresh water creek to brackish and marine environment and back to fresh water occur. At this period, fishes that were in the adjoining flood plains and swamps begin to return to the main stream of the creek, the climax of which is in the month of November. Thus, the estimated catch and potential of 2.16 metric-tons km⁻². Hence, catch and potential yield in number gave mean value of 2,243 individuals per day, while daily estimate of 1,027 fish and standing stock of 4.72 individuals/km². This was high relative to the observation of Abowei (2000) in other aquatic systems of the Niger Delta.

References

- Abowei J. F.N. (2000). Fish stock assessment in the fresh water reaches of the lower Nun River, Bayelsa State, Nigeria. Ph.D. thesis, University of Port Harcourt, Nigeria.
- Bankole N.O. (1990). Gill-net monitoring at Tifa and Jakaran reservoir in Kano State National Institute for Freshwater Fisheries research (NIFFR). Annual Report. PP 39-34.
- Edoghotu, A. J. George, U.U. and Hart, A. I., (2016). The ichthyofauna and physico-chemical properties of Kugbo Creek in the Niger Delta, Nigeria. *New York Journal of Science*. **9**(4): 65-74.
- Fabrizio N., Maurizio G., Alessandrini A., Vespe M., and Paulrud A., (2015). Mapping fishing effort through AIS data. <https://doi.org/10.1371/journal.pone.0130746>
- FAO (1990). Field guide to the commercial marine resources of the Gulf of Guinea. Food and Agricultural Organization regional office for Africa, 163pp.
- Hinz, H., I. G. Murray, G.I. Lambert, I. G. Hiddink and M.J. Kaiser, (2012). Confidentiality over fishing effort data threatens science and management progress.
- Idodo-Umeh, G. (2003). Freshwater fishes of Nigeria (taxonomy, ecological notes, diet and utilization). Ido-Umeh Publishers. Benin City, Nigeria, pp122
- Ita E.O. and M. Machili (1997). The current status on fish stock and fisheries in Kainji Lake. Consultancy report on fish stock assessment in Kainji Lake to the Nigerian-German (GTZ) Kainji Lake Fisheries Promotion Project, New Bussa, pp.28.
- Reed, W. (1967). Preliminary survey of the freshwater fishery of Nigeria, Lagos.
- Stainberg, R. (1964). Monofilament gill-nets in freshwater experiment and practice. Modern Fishing Gears of the World. FAO Fishing Gear Congress. Fishing News Book Ltd, London. Pp11-115.
- Stewart, K.R., R. L. Lawson, D. C. Dunn, R.H. Bjorkland, S. Kelez, P. N. Halpin, and L. B. Crowder (2010). Characterizing fishing effort and spatial extent of coastal fisheries. <https://doi.org.110.1371.journal.phone.0014451>.
- The Federal Government of Nigeria, (1992). Gazette on Fisheries Development in Nigeria. Federal Ministry of Agriculture.
- Ufodiye, B.D.C. A.D. Anthony and O.S. Abda (1989). Study on the influence of the gill-net technology and diurnal variation on the catches in Quree Reservoir. *Miangou, Plateau State Journal of Aquatic Science* 4: 17-19.

Table. 1: Mean fish count and biomass (kg) per mesh size fish caught per net mesh in the kugbo Creek during March 2009 – February 2011.

Mesh (inch)	No of fish	% composition	Biomass (kg)	% composition
¾"	35	1.53	0.97	0.04
1"	63	2.81	5.35	0.26
1½"	26	1.16	8.81	0.43
1¾"	815	36.34	205.49	10.00
2½"	653	29.11	981.31	47.78
3¾"	223	9.94	337.06	16.41
4"	48	2.14	110.83	5.40
7"	21	0.94	130.0	6.33
Total	2,243	100	2,054.00	100

Table 2: Monthly mean variation in catch© and biomass(Bm) of fish caught per net mesh in the Kugbo Creek during the study period.

Mesh	Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		Jan		Feb		Total	
	C	Bm	C	Bm	C	Bm	C	Bm	C	Bm	C	Bm	C	Bm	C	Bm	C	Bm	C	Bm	C	Bm	C	Bm	C	Bm
¾"	0	0	0	0	0	0	6	0.20	10	0.30	3	0.09	9	0.22	5	0.07	2	0.07	0	0	0	0	0	0	35	0.97
1"	2	0.15	3	0.24	9	0.43	2	0.15	15	1.38	16	1.78	2	0.15	7	0.33	4	0.29	1	0.15	1	0.15	1	0.15	63	5.35
1½"	1	0.25	0	0	2	0.30	0	0	0	0	4	1.02	0	0	1	0.25	10	4.15	6	2.54	2	0.30	0	0	26	8.81
1¾"	58	9.26	26	3.05	15	0.650	9	9.49	13	1.80	43	5.77	10	0.94	49	2.15	81	6.82	21	11.60	19	6.79	25	10.16	359	68.43
2"	72	31	62	31	52	9	13	6	21	7	73	14	37	6	48	16	75	22.10	50	27	61	8	89	10.8	653	274.18
2½"	105	71	108	66	11	108.9	52	99.33	5	28.2	20	61	3	33	6	58	11	115	91	110	141	86	334	97	815	932.54
3½"	21	54	17	60	11	74.06	6	45	9	33	20	66.04	13	29	28	37	21	71	16	69.02	29	80	32	56	223	674.12
4"	5	4.2	5	4	3	5	015	0	0	0	8	15	0	0	2	3	9	12.4	5	5.8	7	9	4	5.2	48	10.83
7"	2	6.1	1	2.8	0	0	0	0	7	0	2	5.6	0	0	1	2.5	4	10	0	0	0	0	4	3	21	30.00
Total	266	175.56	222	167.09	1103	197.58	88	160.17	80	71.5	189	170.66	74	69.31	147	115.3	27	241.83	118	226.11	260	190.24	489	182.31	2243	2054.00
% composition	11.8	8.55	9.9	8.13	4.6	9.62	3.9	7.80	3.6	3.48	8.4	8.31	3.3	3.34	6.5	5.63	9.6	11.77	5.2	11.00	11.5	9.26	21.7	8.88	100	100

Table 3: Catch (C) and biomass (Bm)kg of fish caught per sampling zoneper net mesh in Kugbo Creek.

Mesh	Zone1		Zone2		Zone3		Total		%Composition	
	Bm	C	Bm	C	Bm	C	Bm	C	Bm	C
¾"	0.23	9	0.28	13	0.46	23	0.97	45	0.05	2
1"	1.36	14	2.15	28	1.85	21	5.36	63	0.27	2.81
1½"	1.95	5	3.12	10	3.74	11	8.81	26	0.44	1.16
1¾"	20.70	43	25.16	58	22.57	50	68.43	115	3.41	5.13
2"	92.16	178	65.19	116	116.83	262	274.18	556	13.67	24.92
2½"	154.55	211	286.88	278	491.11	364	932.54	853	46.51	38.03
3½"	228.67	180	217.82	167	227.63	176	674.12	523	33.61	23.32
4"	2.45		3.21		5.17		10.83		0.12	2.14
7"	13.44	6	9.32	3	7.24	2	30.00	11	1.50	0.49
Total	515.51	657	613.13	689	876.71	930	2005.24	2243	100	100
% composition	25.71	28.87	30.57	30.27	43.72	40.86	100	100		

Table 4: Fishing effort and catch per unit effort of fish caught in Kugbo Creek.

Months	Catch		Fishing Effort (hours)		Catch per Unit Effort	
	Catch	Biomass	Catch	Biomass	Cash	Biomass
March	196	175.6	12	12	17	14.6
April	279	167.1	12	12	24	13.9
May	163	197.6	12	12	14	16.5
June	93	160.2	12	12	8	13.4
July	89	71.5	12	12	78	6.0
August	212	170.7	12	12	18	14.2
September	84	69.3	12	12	7	5.8
October	147	115.3	12	12	13	9.6
November	444	241.8	12	12	37	20.2
December	398	226.1	12	12	34	18.8
January	210	190.2	12	12	18	15.9
February	181	10.3	12	12	16	0.9
Total	2496	2054	144	12	284	14.2

Table 5: Estimated vital production parameter of exploited fish number caught and biomass (kg) in Kugbo Creek.

S/N	Parameters	Catch Number	Biomass (kg)
1	Number of hours	144	144
2	Total catch	2243	2, 054kg
3	Mean catch/hour	4	14.2kg
4	Mean catch/day	172	171.2kg
5	Total catch/day	187	1,027tons
6	Total Area	75km ²	75km ²
7	Total catch and biomass (ton) per km ²	2154	2.2 tons

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Evaluation of the Status of Artisanal Fishing Gear in the Lower Taylor Creek Area, Bayelsa State, Nigeria

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Abstract

This study evaluated the status of artisanal fishing gear in the Lower Taylor Creek Area, Bayelsa State, Nigeria between January and December, 2019. All the fishing locations were visited to ascertain the current fishing gear that are used and the ones that are no longer in use by the artisanal fishers at the Lower Taylor Creek Area, through direct observation and interviews with the fishers. The results showed that 21 different artisanal fishing gear are currently used at the Lower Taylor Creek Area. The artisanal fishing gear include: Birin-kasa, Isoun-dii, Eleli-dii and Yemu-dii (Gill nets), Atallai (Lift net), Spear (Oborowei), Ingo, Ikara, Gura, Ideribo, Indiba-Angba, and Trap (Owonro), Cast net (Igbo), Seine net (Agodou) and Hook and line/longlines (Meri-meri, Sara-dai, Fungu-dai, Kpokpo-dai) and Fence (Sangu/Ekpe/Kpeki), Scoop net (Agbunu) and Drift net (Teimo-dii) and 12 of the fishing gear are no longer been used they include Traps (Igogo, Eteu/Ortow, Asoro, Agbunu, Kana and Zuyi), Seine nets (Dala and Keli-keli), Hook and line/longlines (Gbemo-dai, Lemo-dai and Bara-dai), and Imbiowei (Spear). This research has established the fact that some of the fishing gear that were used in the Lower Taylor Creek Area previously in capturing fish are no longer in use due to their poor performance, difficulty in construction, extinction of targeted fish species and introduction of new fishing gear with better performance. This study therefore recommends that some of the artisanal fishing gear currently used in the study area should be modified to reduce the capture of non-targeted fish species and as well improve their performance.

Keywords: Evaluation, Fishing gear, Lower Taylor Creek, Status

Introduction

Fishing is the predominant activity carried out by the inhabitants living along the bank of the Lower Taylor Creek Area. This activity is achieved by using implements called fishing gear. Fishing gear (devices) are any kind of equipment or implement used in harvesting or capturing fish from any water body (Nuhu and Yaro, 2005; Kingdom and Kwen, 2009; Tagago and Ahmed, 2011; Kwen *et al.*, 2013). Traps are small or large structures that allows fish to enter voluntarily but make their exit difficult as a result of the presence of chambers and non-return valves (Kwen *et al.*, 2019). Kingdom and Kwen (2009) noted that the major fishing gear employed by artisanal fishers in the Lower Taylor Creek area are traps which accounts for 60% of the total fishing gear been used. This is often achieved by putting chambers or non-return valves in the trap that can be closed once the fish enters, having a funnel shape that makes it difficult for the fish to escape (Gray *et al.*, 2007, Davies and Kwen, 2012).

The Lower Taylor Creek is one of the numerous water courses that is connected to both the Nun River and Orashi River in the Niger Delta at the northern end of the Creek, which are naturally blessed and endowed with diversity of fish species which flows into the Lower Taylor Creek (Kingdom and Kwen, 2009). Thereby, making the Lower Taylor Creek economically important and rich in biodiversity. This has resulted to the use of several fishing gear in the Creek at different seasons to capture a variety of fish species by indigenes and immigrants for the purpose of fishing. Despite these enormous fishing gear used for fishing operations by artisanal fishers in the Lower Taylor Creek, the status of fishing gear in the Lower Taylor Creek has not been upgraded for a long time. It is as a result of this reason, this study is being carried out to evaluate the current status of artisanal fishing gear used in the Lower Taylor Creek Area, Bayelsa State, Nigeria. Though a similar study of this kind was conducted by Kingdom and Kwen (2009) at the Lower Taylor Creek Area, which was on the survey of fishing gear and methods in the Lower Taylor Creek Area. The results from this study shall therefore contribute basic information to the artisanal fishers, scholars and fisheries extension workers.

Materials and Methods

Study Area

The study was carried out in the Lower Taylor Creek Area in Yenagoa Local Government Area, Bayelsa State, Nigeria. The area is a lotic non-tidal fresh water environment and is situated between latitudes 5° 01' and 5° 02' North and longitudes 6° 17' and 6° 18' East (Figure 1). Several creeks and flood channels interconnect fresh water swamp forest, linking the Nun River and Taylor Creek at various points and form a mass of water body during the high flood. These creeks and swamps with their associated floodplain lakes and fishing ponds constitute the main fishing system. Okoso Creek is at present the most prominent creek connected to the Taylor Creek which consequently empties in to the Nun River at its confluence at Polaku community. The Taylor Creek is subjected to mild tidal influence in the dry season. Water flows swiftly in one direction during the flood season but gently in the low water period. The creek system serves the residents in different forms ranging from domestic to commercial cassava tuber fermentation, washing of clothes, fetching water for drinking, fishing, bathing, waste disposal and sand mining. Lower Taylor Creek runs through vegetation that has palm trees, silk cotton and mahogany trees which stand in the flood free farmlands close to the creek. The creek is economically important and rich in biodiversity. Presently, oil exploration and exploitation activities and other rural developmental programs are going on in the area.

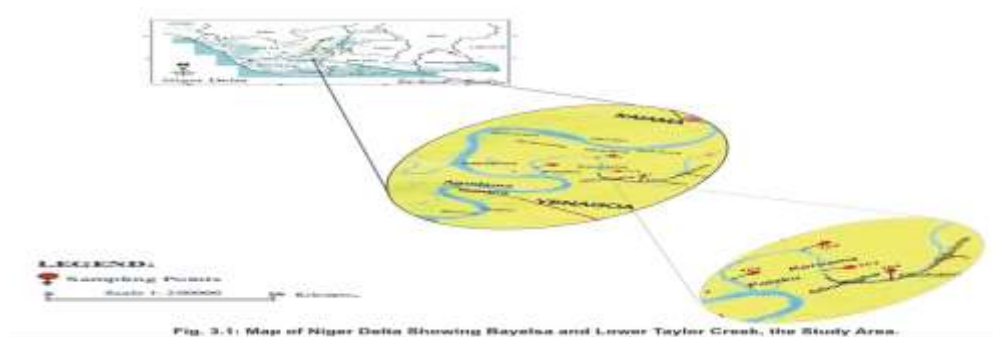


Fig. 3.1: Map of Niger Delta Showing Bayelsa and Lower Taylor Creek, the Study Area.

Sampling Procedure

Sampling was carried out between January and December, 2020 covering both dry and wet seasons in order to identify the artisanal fishing gear currently been used and the ones no longer used in the Lower Taylor Creek Area. All the fishing locations were visited to ascertain the current fishing gear that are used and the ones that are no longer in use by fishers in the Lower Taylor Creek Area, through direct observation and interviews with the artisanal fishers.

Results

The results showed that 19 different fishing gear are currently used in the Lower Taylor Creek Area which include Gill nets (Birin-kasa, Isoun-dii, Eleli-dii and Yemu-dii), Lift net (Atallai), Spear (Oborowei), Traps (Ingo, Ikara, gura, Ideribo, Indiba-Angba and Oworon), Cast net (Igbo), Seine nets (Agodou), Hook and line/longlines (Meri-meri, Sara-dai, Fungu-dai, Kpokpo-dai), Fence (Sangu/Ekpe/Ekpeki), Scoop net (Agbunu) and Drift net (Teimo-dii) (Table 1). Plates 1 to 16 depict photographs of some of the artisanal fishing gear currently used in the study area.

Table 1: Artisanal fishing gear currently being used in the Lower Taylor Creek Area

Standard name of gear	Local/Tribal name of gear
Gill nets	Birin-kasa, Isoun-dii, Eleli-dii, Yemu-dii
Left net	Atallai
Spear	Oborowei, Dumu, Okponu
Traps	Ingo, Ikara, Gura, Ideribo, Indiba-Angba, Oworon,
Cast net	Igbo
Seine nets	Agodou,
Hook and line/longlines	Meri-meri, Sara-dai, Fungu-dai, Kpokpo-dai
Fence	Sangu/Ekpe/ Ekpeki
Scoop nets	Agbunu
Drift nets	Teimo-dii



Plate 1: Biseni (Funnel basket) trap



Plate 2: Metal Drum (Cylindrical Metal) trap



Plate 3: Malian (Conical basket) trap



Plate 4: Ideribo (Funnel basket) trap



Plate 5: Ikara (Rectangular basket) trap



Plate 6: Ingo (Rectangular basket) trap



Plate 7: Hand hook and line



8: Two chambers Malian (Basket) Trap



Plate 9: Circular Scoop(Agbunu) Net



Plate 10: Two chambers Ingo (Rectangular basket) trap



Plate 11: Longline (Mari-mari)



Plate 12: Set gill-net



Plate 13: Longline (Saradii)



Plate 14: Gill-net (Elelidii)



Plate 15: Spear (Ogborowei)



Plate 16: Cast-net (Igbo)

Table 2 presents the artisanal fishing gear that are no longer used by the fishers in the Lower Taylor Creek Area. The results revealed that 12artisanal fishing gear such as Traps(Igogo, Eteu/Ortow, Asoro, Agbunu, Kana and Zuyi), Seine nets(Dala and Keli-keli), Hook and line/longlines(Gbemo-dai, Lemo-dai and Bara-dai), and Spear(Imbiowei) were no longer in use in the Lower Taylor Creek Area.

Table 2: Artisanal fishing gear no longer been used in the Lower Taylor Creek Area

Standard name	Local/Tribal name in the area
Traps	Igogo,Eteu/ortow, Asoro, Agbunu, Kana, Zuyi
Seine net	Dala, Keli-keli
Hook and line/longline	Gbemo-dai, Lemu-dai and Bara-dai
Spear	Imbiowei

Reasons why some artisanal fishing gear are no longer used by artisanal fishers in the study area

1. Poor performance (low catch rate) of fishing gear
2. Difficult to construct
3. Extinction of targeted fish species
4. Introduction of new fishing gear with better performance
5. The fishing gear is restricted by government

Discussion

The fishing gear identified are similar to those identified by Kingdom and Kwen (2009) in the same location along the Taylor Creek axis. Although, some of the fishing gear that were used in the creek by fishers as reported by Kingdom and Kwen (2009) are no longer in use in the study area. The possible reasons why these fishing gear are no longer in use could be attributed to the poor performance of the gear and the introduction of new fishing gear into the study area. The observed fishing gear in this study were also identified in other water bodies in Bayelsa State by

the National Institute for Freshwater Fisheries Research (NIFFR) (2002), when the institute surveyed all the inland water bodies in Nigeria to ascertain the types of fishing gear and crafts used in the country. These were also the commonest fishing gear identified in Kainji Lake (Yisaet *al.*, 1995; Du-feu *et al.*, 1997), Lake Alau (Bankoleet *al.*, 2003) and Lake Chad Basin (Bene and Neiland, 2003). It is pertinent to note that, the commonest fishing gear used in this creek are traps, hook and line/longlines and gill nets which are all passive and have lower rate of by-catch due to their designs in the area and less likely to alter the substratum (Jennings and Kaiser, 1998). However, fishing gear such as traps and gill nets are associated with issues of ‘ghost fishing’ or unintentional catch. This is as a result of loss of fishing gear into the water body which are no longer under the control of a fisher or fishers due to wave actions, currents, storms, sedimentation and gear conflict factors like the entanglement of fishing gear with other vessels or bottom topography such as reefs or rocky bottoms and in-appropriate disposal of fishing gear at sea, river, creek, stream and lake (Jennings and Kaiser, 1998; Bene and Neiland, 2003).

Conclusion

It is evident from the research that, a total of twenty-one different artisanal fishing gear are currently been used in the Lower Taylor Creek Area and twelve of the fishing gear used previously are no longer been used. This research has established the fact that some of the fishing gear that were used in the Lower Taylor Creek Area previously in capturing fish are no longer been used due to their poor performance, difficulty in construction, extinction of targeted fish species and introduction of new fishing gear with better performance. Based on the finding of this research, it is therefore recommended that some of the artisanal fishing gear currently been used should be modified to reduce the capture of non-targeted fish species and as well improve their performance.

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References

- Bankole, N.O., A. Raji, L.A. Adikwu and Okwundu, F. C. (2003). Fishing Gear Survey of Lake Alau. In: A. A. Eyo and E. A. Ajao (Eds.). *Proceedings of the 16th Annual Conference of the Fisheries Society of Nigeria (FISON)*. 29th-3rd December, 2004, Kwara Hotels Limited, Ilorin, Nigeria. Pp.99-103.
- Bene, C. and Neiland, A. C. (2003). Contribution of Inland fisheries to rural livelihoods in Africa: An overview from the Lake Chad basin areas. In: Welcome, R. and Petr, T. (Eds.). *Proceedings of the Second International Symposium on the Management of Large Rives for Fisheries*, Vol. 11. FAO Reg. Office for Asia and the Pacific, Bangkok, Thailand, RAP Publication, Pp. 1-14.
- Davies, O. A. and Kwen, K. (2012). Fish assemblages of selected Traditional Fishing traps (Malian and Ikara) in the Upper Nu River, Niger Delta, Nigeria. *FS Journal of Basic and Applied Sciences*, Vol. 1. No 2:8-11.
- Du-feu, T. A., Abayomi, O. S. and Seisay, M. D. B. (1997). Fishing gear survey, Kainji Lake, Northern Nigeria. *Nigeria German Kainji Lake Promotion Technical Report*, No. Pp. 6: 20.
- Gray, M. S., T. Hechtand and Sauer, W. H. H (2007). On the feasibility of a directed trap-fishery for *PangapterogymnusLaniarius* (Sparidae) in South Africa. *African Journal of Marine Sciences*, 29(3): 465-472.
- Jennings, S. and Kaiser, M. J. (1998). The effects of Fishing on Marine Ecosystems. *Advance Marine Biology*. 34. 201-352.
- Kingdom, T. and Kwen, K. (2009). Survey of fishing gear and methods in the Lower Taylor Creek Area, Bayelsa State Nigeria. *World Journal of Fish and Marine Sciences*, 1(4): 313-319.
- Kwen, K., Davies, O.A. and Binyotubo, T.E. (2013). Survey of fishing gear and status of fishers in Igbedi Creek, Niger Delta, Nigeria *International Journal of Scientific Research in Knowledge (IJSRK)* 1 (11): 493 – 501.
- Kwen, K., Ewutanure, J. S. and Binyotubo, T. E. (2019). Zooplankton species diversity and physico-chemical parameters in the Lower Taylor Creek Area, Bayelsa State, Nigeria. *American Journal of Engineering Research (AJER)* ISSN:2320-0936. Volume 8, Issue 6. Pp. 94-99.
- National Institute for Freshwater Fisheries Research (2002). National survey of fishing gears and crafts on Nigerian inland water bodies. *National Institute for Freshwater Fisheries Research Occasional Paper 4.54 p*.
- Nuhu, M.B and Yaro, I. (2005). Selection of efficient hanging ratio of gillnet on fish catch in Lake Kainji, as means of alleviating poverty among artisanal fishermen in Nigeria. In: P.A. Araoye (Ed). *Proceedings of the 19th Annual Conference of the Fisheries Society of Nigeria (FISON)*. Ilorin, 29th-3rd December, Kwara, Nigeria Pp. 64-72.

- Tagago, T. A. and Ahmed, Y. A. (2011). Fishing gear survey of Tatabu floodplain, In: R.J.Koko and A.M. Orire (Eds). *Proceedings of the 26th Annual Conference of the Fisheries Society of Nigeria (FISON)*. 28th November– 2nd December, Minna, Niger State, Nigeria.PP.109 – 116.
- Yisa, Z., Apeloko, F. and Kasali, A. (1995). Fishing gear survey of Kainji Lake, *NIFFR Annual Report*, Pp. 212-215.

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Improving Protein- Based Nutrition through Fish Consumption: An Assessment Of Knowledge, Attitude And Practices of Low Income Earners in Abakaliki, Ebonyi State, Nigeria

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Abstract

Fish is one of the healthiest meals on the planet, packed with nutritional vitamins that are essential for the body, eyes, skin and brain development in children and adults. Fish is also one of the cheapest animal protein source for man and animals. In order to improve protein- based nutrition through fish consumption: an assessment of knowledge, attitude and practices of low income earners in south eastern Nigeria was conducted in Abakaliki, Ebonyi State using quantitative methods and analysis was done by the Likert rating scale. Results showed that most of the respondents were males between the ages 18-30 years old, had tertiary education, earned between ₦5,000 - ₦10,000/month, were business men, unmarried and had no offspring. Respondents' knowledge about nutritional value of fish was relatively high (3.81) while knowledge of the effort/policy the government to improve fish availability for consumption was very low (2.66). Attitude towards fish consumption of the respondents was relatively high (3.50-3.98). The outcomes of the respondents' practices regarding fish consumption were relatively low ranging from 2.80-3.39. The most important factors responsible for low frequency in consumption and advocacy are availability, accessibility and affordability of fish for consumption. Therefore there is need to put in more effort into government policy to improve fish availability for consumption. Establishment of more government owned fish ponds /farms for fish production (aquaculture) will boost access to fish products for consumption. Reducing the cost of fish will also enhance the capacity to buy more fish for consumption.

Keywords: Food, Fish, Knowledge, Attitude, Low income

Introduction

Fish is food for many species, which consists of humans. Fish affords a correct supply of high quality protein and contains many vitamins and minerals (Ruxton *et al.*, 2004; Banda-Nyirenda *et al.*, 2009). Fish is among the healthiest foods on earth which is packed with essential nutrients, such as protein, vitamin D and omega-3 fatty acids, which are highly important for body and brain development (Ruxton *et al.*, 2004; Albert *et al.*, 2005; Bäärnhielm *et al.*, 2014). Fish is generally considered to be among the high quality foods consumed for a healthy heart (Malesa-Ciećwierz *et al.*, 2015). Studies have proven that humans who eat fish regularly seem to have decrease danger of coronary heart attacks, strokes and loss of life from coronary heart disease (Djoussé *et al.*, 2012, Zheng *et al.*, 2012, Chowdhury *et al.*, 2012, Buscemi *et al.*, 2014). According to Chen *et al.*, 2022 research evidence has proven that regulated fish consumption has notable health benefits such as anti-oxidation, anti-inflammation, wound healing, neuroprotection, cardioprotection, hepatoprotection, antiviral, antibacterial properties and prevention of protein-calorie malnutrition. Eating fish is also known to improve sleep quality because it contains vitamin D (Malesa-Ciećwierz and Usydus, 2015). Fish can be prepared easily, it is tasty and is easily digestible however data on the perception of fish consumption is limited. Therefore this research seeks to generate scientific information that will inform policy for improvement of nutrition among low income earners by determining of the knowledge of the target population concerning fish based nutrition, evaluating the attitudes of target population towards fish consumption and assessing the practices of target population regarding fish consumption.

Materials and Methods

Study Area

Abakaliki is the capital city of Ebonyi State in southeastern Nigeria, bounded to the north by Enugu State, south by Cross River State, west by Abia State with coordinates: 6°20'N 8°06'E. Abakaliki falls under Abakaliki local government area (LGA), one of the fourteen (14) LGAs in Ebonyi State. Latest population estimation of Abakaliki

was 915,438 (year 2019), 0.253% of total Nigerian population. However, it is estimated that the population of Abakaliki as at 2021 is about 1,179,280 if population growth rate is 15.31%/year (Oriji, 2011). Abakaliki is known as a center of agricultural trade including such products as vegetables, yams, cassava, palm oil, palm kernels and the popular Abakaliki rice (Hoiberg, 2010). The populace also engage in piggery, poultry and fish farming. Mining and quarrying, are common activities peculiar to the area (Cohen, 1998).

Data collection

Data collection was conducted between October-December 2015 within the state capital. The individual survey questionnaire was designed to collate answers to generate scientific information on the knowledge, attitudes and practices of target population regarding fish consumption. The questionnaire was developed as a 5-point Likert scale structured questionnaire which was pre-tested and validated. In-depth analysis of the key issues relating to the pattern of the questionnaire and appropriateness of the terminologies were considered during the questionnaire development stage. This was followed by a pilot test on a limited number of respondents to ensure that the intended respondents will adequately understand the questionnaire and give correct responses. The survey was targeted at individuals of low wealth households (living in the ghetto/ make shift houses), junior workers and petty traders. Random sampling method was used to conduct the survey in which every other individual of every other household, office or market shed was given a questionnaire to fill. The questionnaires were distributed by the lead researcher and seven assistant researchers. The questionnaires were self-administered to consenting and willing participants who were literate, those who could not speak English were assisted to complete the questionnaire by the research assistants, who spoke the local language of the respondents. Each interview lasted approximately 15 minutes. The data quality control was done by the lead author and a total number of seventy (70) completed questionnaires were collected.

Analysis of the questionnaire

The data collected via the questionnaires was analyzed using the methods developed at McMaster University Canada (Johnson and Lavis 2009). The main parameter measured was participants' perceptions of their own knowledge/understanding. The analysis is based on mean rating (MNR), median rating (MDR) and range. For instance the figures represent Likert rating scale of 1-5 points, where 1 point = grossly inadequate; 2 points = inadequate; 3 points = fairly adequate; and 4 points = adequate; and 5 points = very adequate.

The range was recorded as the range of values represented by lowest number chosen from the response scale and the highest (e.g., 2-5). The mean was calculated as the numbers chosen from the response scale and divide by the total number of responses to the question. The median was determined by arranging the values chosen from the response scale in ascending order. In terms of analysis, values ranging from 1.00-3.49 points are considered low, whereas values ranging from 3.50-5.00 points considered high.

Results

Biodata of the respondents

A total of 70 questionnaires were distributed among the low income earners in the Abakaliki metropolis of Ebonyi state. A total of 36 (51.43%) of the respondents were males, while 34 (48.57%) were females (Table 1). Most of the respondents (51.43%) were between the ages of 18-30 years old and the least of that populace (4.29%) were above 60 years old (Table 2). 36 (51.42%) of the respondents had tertiary education with only 1 (1.43%) having no formal education (Table 3). Half of the respondents (50.00%) earn between ₦5,000 - ₦10,000/month (Table 4). A total of 38 (54.29%) respondents were business men and women with a few (4.29%) being applicants (Table 5). 38 (54.29%) of the respondents were unmarried while 32 (45.71%) were married (Table 6). Most of the respondents 52.86% had no offspring while the respondents with 1-2 offsprings were the least (Table 7).

Table 1: Age frequency distribution of the respondents

Age	Frequency	Percentage (%)
18-30	36	51.4
31-40	17	24.3
41-50	9	12.9
51-60	5	7.1
>60	3	4.3
Total	70	

Table 2: Gender distribution of the respondents

Gender	Frequency	Percentage (%)
Male	36	51.4
Female	34	48.6
Total	70	

Table 3: Educational level of the respondents

Educational level	Frequency	Percentage (%)
Nil	1	1.4
Primary	9	12.9
Secondary	24	34.3
Tertiary	36	51.4
Total	70	

Table 4: Income level of the respondents

Income level/month	Frequency	Percentage (%)
₦5,000 - ₦10,000	35	50.0
₦11,000 - ₦20,000	15	21.5
₦21,000 - ₦30,000	8	11.4
₦31,000 - ₦40,000	4	5.7
> ₦40,000	8	11.4
Total	70	

Table 5: Occupational status of the respondents

Occupational status	Frequency	Percentage (%)
Applicant	3	4.3
Civil Servant	12	17.1
Business	38	54.3
Student	17	24.3
Total	70	

Table 6: Marital status of the respondents

Marital status	Frequency	Percentage (%)
Single	38	54.3
Married	32	45.7
Total	70	

Table 7: Number of offspring of the respondents

No. Of offspring	Frequency	Percentage (%)
Nil	37	52.9
1-2	8	11.4
3-4	13	18.6
5-6	12	17.1
Total	70	

Knowledge of fish nutritional value

The outcome of the respondents' knowledge of fish nutritional value is presented in Table 8. The result showed that respondents' knowledge about nutritional value of fish was relatively high as indicated by mean rating of 3.81 (adequate). However, in terms of knowledge of the effort/policy the government to improve fish availability for consumption, the mean rating was very low (2.66, inadequate) (Table 8).

Table 8: Knowledge of fish nutritional value

Question	Range	Median	Mean
1. Level of knowledge about nutritional value of fish	1-5	4	3.81
2. Level of understanding about the cost of fish-based meal	1-5	3	3.11
3. Level of knowledge on the preparation of fish-based meal	1-5	4	3.50
4. Level of knowledge on the source of procurement of fish for consumption	1-5	3	3.28
5. Level of knowledge on the effort/policy the government to improve fish availability for consumption	1-5	2	2.66

Attitude towards fish consumption

The result of the respondents' individual attitude towards fish consumption is presented in Table 9. The result showed that respondents' willingness to eat fish-based meal as main source of protein, willingness to buy fish at present cost for consumption instead of other animal sources of protein, willingness to support the effort/policy of the government to make fish available for the population and the present cost of fish for consumption were relatively high as indicated by mean rating that ranged from 3.50-3.98 (Table 9).

Table 9: Attitude towards fish consumption

Question	Range	Median	Mean
1. Willingness to eat fish-based meal as main source of protein	1-5	4	3.98
2. Willingness to buy fish at present cost for consumption instead of other animal sources of protein	1-5	4	3.58
3. Willingness to support the effort/policy of the government to make fish available for the population	1-5	4	3.50
4. Description of the present cost of fish for consumption	2-5	4	3.78

Practices regarding fish consumption

The outcome of the respondents' practices regarding fish consumption is presented in Table 10. The mean ratings based on practices were relatively low and ranged from 2.80-3.39 (Table 10).

Table 10: Practices regarding fish consumption

Question	Range	Median	Mean
1. Frequency of fish consumption	1-5	3	3.01
2. Frequency of use of fish for meal preparation	2-5	3	3.39
3. Description of the effort of the government to encourage small scale fish production to enhance local availability	1-5	2	2.80
4. Frequency of advocacy for fish consumption	1-5	3	3.16

Discussion

This study indicated sufficient knowledge about the nutritional value of fish which is in agreement with a study involving hundreds of thousands of participants who indicated that eating approximately one to two 3-ounce servings of fatty fish (salmon, herring, mackerel, anchovies, or sardines) a week reduces the risk of dying from heart disease by 36 percent (Mozaffarian and Rimm, 2006). According to Wang *et al.* (2006), the contribution of fish to human nutrition and its impact on health have been examined from different aspects in both developed and developing countries and in developed countries, researchers and consumers have been interested in the health benefits of poly-unsaturated fatty acids (PUFAs), which lower blood pressure, reduce the risk of heart disease, and possibly support infant growth and cognitive development (Koletzko *et al.*, 2007). According to Kawarazuka (2010), malnutrition, micronutrient deficiencies, and HIV/AIDS are the main public health problems related to nutrition in developing countries. The role of fish in contributing to nutritional needs has been highlighted in public health and fisheries literature, although the data are negligible compared to studies from developed countries (Kawarazuka, 2010). The respondents' understanding about the cost of fish-based meal was fairly adequate; this may be connected with price differences among different sizes and species of fishes. Respondents' knowledge of the preparation of fish-based meal was adequate which is in line with the typical diet of the poor as stated by Kawarazuka (2010) which is dominated by staple foods with small amounts of other plant-source foods such as vegetables and animal-source foods. The author noted that by diversifying diet by adding animal-source foods,

fruits and vegetables in their diets provides a variety of nutrients, contributing to improving nutritional status. The respondents' knowledge of the source of procurement of fish for consumption was adequate which is basically in the markets. The results obtained from this study indicated insufficient knowledge on effort/policy of the government to improve fish availability for consumption. This study also revealed that a positive attitude towards fish consumption which include willingness to eat fish-based meal as main source of protein, to buy fish at present cost for consumption instead of other animal sources of protein, to support the effort/policy of the government to make fish available for the population despite the present cost of fish. This is in agreement with the findings of FAO (2009a, b) which stated that fish is still nutritionally important in many African countries as well as in Asia and Oceania and that a large majority (73%) of the countries where fish is an important source of animal protein are poor and food deficient countries. The low frequency in fish consumption and in advocacy is in agreement with the report of Von Braun *et al.*, 2008; UNSCN, 2009, that poor households have generally limited income for food consumption therefore they tend to prioritize certain food items. According to Béné *et al.* (2003), Karim (2006) and Islam (2007), availability of staple foods is one of the determinants of fish consumption patterns of the poor and when households lack food, fish produced by aquaculture or supplied by common-pool resources are used for cash, rather than as food for household consumption which is in line with this study. The study also indicated less effort on the part of the government to encourage small scale fish production. The most important factors responsible for low frequency in consumption and advocacy are availability, accessibility and affordability of fish for consumption.

Conclusion

Sufficient knowledge about the nutritional value of fish, effort/policy of the government to improve fish availability for consumption, a positive attitude towards fish consumption, increased advocacy and more effort by the government to encourage small scale fish production will go a long way in improve protein-based nutrition through fish consumption. Policy makers in the Ministry of Agriculture, the Federal Department of Fisheries (FDF), Fisheries Society of Nigeria (FISON) and other stakeholders should encourage the implementations of policies that will make fish products more abundant and affordable for consumption by the poor masses.

References

- Albert C. M., Oh K. and Whang W. (2005). Dietary alpha-linolenic acid intake and risk of sudden cardiac death and coronary heart disease. *Circulation*. 112: 3232-8.
- Bäårnhielm M., Olsson T., and Alfredsson L. (2014). Fatty fish intake is associated with decreased occurrence of multiple sclerosis. *MultScler*. 20(6):726-32.
- Banda-Nyirenda, D., Husken, S., Kaunda, W. (2009). *The impact of nutrition and fish supplementation on the response to anti retroviral therapy: a literature review*. Penang: WorldFish Centre.
- Béné, C., Neiland, A., Jolley, T., Ladu, B., Ovie, S., Sule, O., Baba, O., Belal, E., Mindjimba, K., Tiotsop, F., Dara, L., Zakara, A. and Quensiere, J. (2003). Inland fisheries, poverty and rural livelihoods in the lake Chad basin. *Journal of Asian and African Studies*, 38(1), 17 - 51.
- Buscemi S., Nicolucci A., Lucisano G., Galvano F., Grosso G., Belmonte S., Sprini., Migliaccio., Cianferotti L., Brandi M. L. and Rini G. B. (2014). Habitual fish intake and clinically silent carotid atherosclerosis. *Nutr J*. 13:2. doi: 10.1186/1475-2891-13-2.
- Chen Jiali, Muthukumaran Jayachandran, Weibin Bai and Baojun Xu (2022). A critical review on the health benefits of fish consumption and its bioactive constituents. *Food Chemistry* 369, (1): 13087
- Chowdhury R., Stevens S., Gorman D., Pan A., Warnakula S., Chowdhury S., Ward H., Johnson L., Crowe F., Hu F. B. and Franco O. H. (2012). Association between fish consumption, long chain omega 3 fatty acids, and risk of cerebrovascular disease: systematic review and meta-analysis. *BMJ*. 345:6698.
- Cohen, Saul B., ed. (1998). "Abakaliki". The Columbia Gazetteer of the World. Vol. 1: A to G. New York, NY: Columbia University Press. ISBN 0-231-11040-5.
- Djoussé L., Akinkuolie A. O., Wu J. H., Ding E. L. and Gaziano J. M. (2012). Fish consumption, omega-3 fatty acids and risk of heart failure: a meta-analysis. *Clin Nutr*. 31(6): 846-53.
- FAO. (2009a). Calculated from food balance sheets. [Online] FAOSTAT (Updated: 18 December 2009) Available at: <http://faostat.fao.org/site/368/DesktopDefault.aspx?PageID=368#ancor>. [Accessed 22 January 2010].
- FAO. (2009b). Low-income food-deficit countries 2009. [Online] FAO country profiles. Available at: <http://www.fao.org/countryprofiles/lifdc.asp> [Accessed 3 November 2009].
- Hoiberg, Dale H., ed. (2010). "Abakaliki". Encyclopedia Britannica. Vol. 1: A-ak Bayes (15th ed.). Chicago, IL: Encyclopedia Britannica, Inc. ISBN 978-0-85229-961-6. LCCN 2002113989

- Islam, F.U. (2007). Self-recruiting species (SRS) in aquaculture: their role in rural livelihoods in two areas of Bangladesh. Ph.D. Thesis, University of Stirling.
- Johnson N. A. and Lavis J. N. (2009). Procedures Manual for the 'Evaluating Knowledge Translation Platforms in Low- and Middle-Income Countries' Study. Hamilton, Canada: McMaster University Program in Policy Decision-Making; 2009.
- Karim, M. (2006). The livelihood impacts of fishponds integrated within farming systems in Mymensingh district, Bangladesh. Ph.D. Thesis, University of Stirling.
- Kawarazuka N. (2010). The contribution of fish intake, aquaculture, and small-scale fisheries to improving nutrition: A literature review. The WorldFish Center Working Paper No.2106. The WorldFish Center, Penang, Malaysia. 51 p.
- Koletzko, B., Cetin, I., Brenna, J. T. (2007). Dietary fat intakes for pregnant and lactating women. *British Journal of Nutrition*, 98, 873 – 877.
- Malesa-Ciećwierz M. and Usydus Z. (2015). Vitamin D: can fish food-based solutions be used for reduction of vitamin D deficiency in Poland? *Nutrition* 31(1):187-92.
- Mozaffarian D. and Rimm E. B. (2006). Fish intake, contaminants, and human health: evaluating the risks and the benefits. *JAMA*. 296:1885-99.
- Oken E., Wright R. O. and Kleinman K. P. (2005). Maternal fish consumption, hair mercury, and infant cognition in a U.S. Cohort. *Environ Health Perspect.* 113:1376-80.
- Orij, John N. (2011). Political Organization in Nigeria Since the Last Stone Age: A History of the Igbo People. New York, NY: Palgrave Macmillan. ISBN 978-0-230-62193-0. LCCN 2010025628
- Ruxton C. H. S., S. C. Reed, M. J. A. Simpson and K. J. Millington (2004). The health benefits of omega-3 polyunsaturated fatty acids: a review of the evidence. *Journal of Human Nutrition and Dietetics* 17 (5): 449–459.
- UNSCN (2009). *Global financial and economic crisis – the most vulnerable are at increased risk of hunger and malnutrition*. SCN Briefs on Nutrition, Geneva: United Nations Standing Committee on Nutrition. Von Braun, J., Ahmed, A., Asenso-Okyere, K., Fan, S., Gulati, A., Hoddinott, J., Pandya-Lorch, R., Rosegrant, M. W., Ruel, M., Torero, M., van Rhee, T., von Grebmer, K. (2008). High food prices: the what, who, and how of proposed policy actions. *IFPRI Policy Brief*.
- Wang, C., Harris, W., Chung, M., Lichtenstein, A., Balk, E., Kupelnick, B., Jordan, H.S., Lau, J. (2006). n-3 Fatty acids from fish or fish-oil supplements, but not α -linolenic acid, benefit cardiovascular disease outcomes in primary- and secondary-prevention studies: a systematic review. *American Journal of Clinical Nutrition*, 84(1), 5 - 17.
- Zheng J., Huang T., Yu Y., Hu X., Yang B. and Li D. (2012). Fish consumption and CHD mortality: an updated meta-analysis of seventeen cohort studies. *Public Health Nutr.* 15(4):725-37.

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Assessment of Information Sources of Extension Workers in Edo State

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Abstract

The study assessed the information sources of extension workers in Edo state. It also examined the type of information they access as well as the barriers to their information access. Edo central and Edo north were randomly selected for the study. Primary data were collected from a random sample of 45 extension workers using questionnaire. The findings revealed that the extension workers frequently sought information from fortnightly meetings (mean=3.89) and television (3.87). Major information sought were improved varieties (mean=3.82) and pest control (3.80). Lack of sponsorship to conferences and workshops (mean=3.62), lack of computers (mean=3.58) and poor electricity (mean=3.56) were the major barriers limiting extension workers access to information. Age ($r=-0.335$) was the only respondents characteristics that had significant influence on their information seeking.

Keywords: Extension, Information, Agriculture, Edo State.

Introduction

The importance of agriculture in the economy of Nigeria is profound. Despite the growth of industries, oil and commerce, it continues to be the principal economic activity of the people of Nigeria. Daudu *et al.*, (2009) reported that 70% of Nigerians are engaged in agriculture, of which 70% operate at subsistence level. Despite the involvement of large percentage of the population in agriculture, the country continues to experience perpetual food shortage and continue to spend the lean foreign reserve on importation of food (Adesoji and Aratunde, 2012).

Over the years, agricultural extension has been at the fore-front in the delivery of relevant information to farmers for increased agricultural productivity. According to Agbamu (2005), agricultural extension service delivery all over the world has been concerned with communicating research findings and improved agricultural practices to farmers. Information flow thus becomes a very critical input in the agricultural development process in the country, as one of the main challenges affecting the adoption of new technologies by farmers is lack of information (Chema *et al.*, 2003). This is because, the information flow process delivers to farmers the required knowledge needed to implement modern systems of farming. In the Nigeria system and in Edo state in particular, the ADP is largely responsible for communicating information on relevant production technique to farmers (Koyenikan, 2011). The Agricultural development programme ADP is therefore a crucial partner in the development process, since it deliver information to farmers. Therefore, the type of information the agency gets and communicates to farmers, to a great extent, is influenced by where it gets the information from,

1. Identify the information sources of the extension workers;
2. Examine the type of information accessed from the information sources; and
3. Examine the barriers that hinder extension workers access to the Objectives

Methodology

Edo central and Edo north were randomly selected for the study. Primary data were collected from a random sample of 45 extension workers using questionnaire. Questionnaire were used to get response from respondents. Data were analyzed using descriptive statistics such as mean and standard deviation.

Results and Discussion

Information Sources of Respondents

Table 1 presents the information sources of respondents in the study area. The result reveals that the respondents frequently get information from all the sources listed in Table 1 since the scores are above 3.0. However, fortnight training FNT meetings (mean= 3.89) and television (mean= 3.87) were more frequently sought sources. This may be

due to the fact that, the extension workers have closer interaction with colleagues as they hold FNT meetings weekly, and also information from television programs are more detailed and visual. Internet (mean= 3.44) and journals/ conference papers (mean= 3.47) were least frequently sought, which may be due to the fact that information from internet are not screened or scrutinized and also lack of funds to get journals/ conference papers.

The type of information frequently sought by respondents in the study area is presented in Table 2. The result reveals that they frequently seek all the type of agricultural information listed in the table. However, information on improved varieties (mean= 3.82) and pest control (mean= 3.80) were the most frequently sought. The reason for this might be based on the prevalent problems confronting farmers in the study area.

Table 1: Information sources of respondents

Sources	Mean*	Std. Deviation
FNT meetings	3.89	1.283
Television	3.87	1.307
Research institutes/universities	3.84	1.167
Text books	3.82	1.319
Radio	3.76	1.282
Conferences	3.53	1.236
Journals/Conference papers	3.47	1.342
Internet (websites)	3.44	1.455

*Frequent mean= 3.0

Table 2 Information sought

Types	Mean*	Std. Deviation
Improved varieties	3.82	.387
Pest control	3.80	.405
Livestock	3.71	.549
Fertilizing/ Chemical application	3.69	.557
Fish farming	3.67	.564
Current prices	3.64	.484
Value chain	3.62	.650
Forecast of market trends	3.53	.726
Agro chemicals and fertilizers	3.53	.625

*Frequent mean= 3.0

Table 3.Barriers to Respondents Information Seeking

Barriers	Mean*	Std. Deviation
Lack of sponsorship to conferences/workshops	3.62	.747
Lack of computers	3.58	.783
Poor electricity	3.56	.841
Low skill in use of internet	3.42	.988
Long bureaucratic process in getting information from research institute/ universities	3.33	.929
Poor internet network	3.29	.843
High cost of internet browsing	3.29	.815
Unwillingness of institutions (research institutes/universities) to share information	1.55	1.126
Do not have current textbooks/journal	3.22	.927

*Serious mean= 2.50

The result as presented in Table 3, shows the barriers to information access by respondents in the study area. The result reveals that all the barriers were serious since the scores are above 2.50. However, unwillingness of institutions to share information (mean= 1.54) was not rated serious which means that institutions, such as research institutes are always willing to share information. However, lack of sponsorship to conferences/ workshops (mean=

3.62) was the most serious compared to other barriers. These barriers are a great hindrance to information access by extension workers. The implication of this is that, effective extension delivery is limited.

Conclusion

From the study, it can thus be concluded that extension workers source information frequently from various sources, especially FNT meetings and television. Also, extension workers sought information on different types of agricultural information especially information on improved varieties and pest control. However, there were barriers limiting the workers access to information, especially lack of sponsorship to conferences/ workshop and lack of computers.

Recommendations

Based on the findings the study therefore recommends the following;

1. Funds should be available to sponsor extension workers to conferences / workshops, to enable them acquire more knowledge on new findings or researches.
2. Extension workers should be trained on how to use internet as low skill in the use of internet was a serious constraint.
3. The management of the Extension service should provide computers as well as internet facilities, and also alternative source of electricity. These will facilitate the workers ability to access important information.

References

- Adesoji, S.A. and Aratunde, T. (2012). Evaluation of the linkage system of Research- Extension-Farmers in Oyo State, Nigeria: Lesson for agricultural extension administrators. *Journal of Agricultural Extension and Rural Development*. 4(20): 561-568
- Agbamu, J. U. (2005). Problem and prospects of agricultural extension in developing countries. In *Agricultural Extension in Nigeria*. S.F. Afolayan. (ed), Ilorin, AESON. pp. 159 -169
- Chema, S., Gilbert, E. and Roseboom, J. (2003). *A review of key issues and recent experiences in reforming agricultural research in Africa*. [London]: International Service for National Agricultural Research (ISNAR). pp. 183-194.
- Daudu, S, Chado, S.S. and Igbashal, .A.A. (2009). Agricultural information Sources utilized by farmers in benue state, Nigeria. *Journal of Faculty of Agriculture, Nasarawa State University Keffi*, 5(1): 39-48. www.google.com (accessed on 2/06/2015)
- koyenikan, M.J. (2011). Extension workers' access to climate information and sources in Edo State Nigeria. *Archives of Applied Science Research*, 3 (4):11-20 <http://scholarsresearchlibrary.com/archive.html> (Accessed on 2/07/2015).

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Assessment of Modern Fish Spawning Technologies amongst Fish Farmers in Delta South Agricultural Zone, Delta State, Nigeria

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Abstract

This study assessed the utilization of modern fish spawning technologies amongst fish farmers in Delta South Agricultural Zone, Delta State. The purposes of the study were to; examine the level of adoption, examine the effects of adoption of improved spawning technology on farmers' income and constraints plaguing the adoption of improved spawning technologies. Multi-stage sampling technique was used to sample 112 respondents from four LGAs of the State. Statistical tool used were descriptive statistics which was used to analyze the objectives and inferential statistics (t-test) was used to analyze the hypothesis of the study. Results obtained revealed that the average farm income of the adopters and non-adopters was ₦347,321.43 and ₦232,535.71 respectively. The difference was ₦114,785.72 and t-value (18.341) indicated that it was significant at the 5% level. Constraints of adoption include lack of funds (mean = 3.11), scarcity of trained manpower (mean = 3.02), high labour cost (mean = 3.72), complexity (mean = 2.95) and incompatibility of technology with culture, norms and tradition (mean = 2.83). The study thus concluded that adoption of the improved spawning technologies have positively impacted on the adopter farmers farm income.

Keywords: fish, spawning, adopters, non-adopters, loans, technologies, adoption

Introduction

Fish farming is an age-long farming activity that involves the raising of fishes through artificial means for human consumption. It has helped households and the nation in achieving food security and poverty alleviation (Esobhawan and Ogundele, 2011). The contribution of fish to man and the nation cannot be overemphasized. However it provides man with his/her protein demand, it generates employment opportunities directly or indirectly for the people who engage in it, it generates income for the people and the nation. (Olagunju, *et al.*, 2007). In spite of its importance the production has not been able to meet up with its demand and this may like be connected to population explosion and possible obsolete technology still been used by many farmers. In order to meet up with the demand for fish, some form of aquaculture information on artificial spawning (which is the release of reproductive gametes of fish (egg and milt) through the aid of reproductive hormone is needed and it is against this background that this study was carried out. The objectives involved to: determine the fish farmers' level of adoption of improved spawning technologies in Delta State, examine the effects of fishfarmers' adoption of improved spawning technologies on income of farmers, and; identify the constraints plaguing the adoption of improved spawning technologies in the study area.

Hypothesis of the study

H₀₁: There is no significant difference in farm income between adopters and non-adopters of improved spawning technologies.

Methodology

Area of Study

The study was carried out in Delta State. It is one of the nine States in the Niger Delta region of Nigeria. The State covers an area of approximately 17,698Km², and its population is 5,663,400 (NPC, 2016) The State has 25 Local Government Areas and the capital is at Asaba while the economic nerve center is at Warri. (AWC, 2006). The State is also rich in agricultural activity like growing of crops and rearing animals. Multi-stage sampling technique was used to sample the respondents of the study. It started with the purposive selection of four (4) LGAs in Delta South Agricultural zone of the State. The LGAs include Isoko North, Isoko South, Patani and Bomadi. The second stage

involved the purposive selection of three (3) different towns per LGA (they are Ozoro, Ofagbe and Owhelogbo from Isoko North LGA; Oleh, Uzere and Emede from Isoko South LGA; Patani town, Odorubu and Adobo from Patani LGA; and Bomadi town, Kpakiamma and Ogbiama from BomadiLGA) and this brought the towns used for the study to twelve (12). The third stage involved the purposive selection of ten (10) registered fish farmers (with Delta Agricultural Development Programme) in each of the selected towns. This brought the total number of respondents used for the study to one hundred and twenty (120) and they were administered with the question instruments. Out of the collected instruments, 112 (93.33%) suitable for analysis were used for the study. For the purpose of comparative analysis, an equivalent number of fish farmers who depend on local breeds of fishes due to their choice or because they do not have access to spawning technologies were equally sampled from the area of study. This made the total number of fish farmers used for the study to two hundred and twenty four (224). Some trained enumerators and extension agents serving in the Delta State Agricultural Development Programme (DADP) were used in reaching the farmers to administer and retrieve the question instruments in the respective LGAs.

Data analytical techniques

Data were generated from primary source that is, from the respondents through the use of questionnaires and interview schedule. Data collected were analyzed using descriptive (which involved use of frequency, percentage and mean for analysis of respondents' effects of adoption and level of adoption of improved spawning technologies. Constraints plaguing the adoption of improved spawning technologies were obtained through a four – point likert type scale, coded 4, 3, 2 and 1 for Strongly Agree, Agree, Disagree and Strongly Disagree respectively. The weighted mean score of 2.50 (which was obtained via $[4 + 3 + 2 + 1] / 4$) was used to determine which constraint was serious and the ones that were not. Values of 2.50 and above are considered important, while those with values less than 2.50 are regarded as not important.

Hypothesis one was analyzed using t-test and it was used to determine if a significant difference existed between mean of two groups (income of fish farmers who adopted improved spawning technologies and those farmers who did not) Madukwe (2004). The formula for t-test is as shown below:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where:

$\bar{x}_1$ = the mean of group 1 ;

$\bar{x}_2$ = the mean of group 2

S_1 = standard deviation for group 1 ; S_2 = standard deviation for group 2

S_1^2 = variance of the first group ; S_2^2 = variance of the second group

n_1 = size of the first group ; n_2 = size of the second group

$\sqrt{}$ = square root

Decision rule for t – statistics: i.e. if $t_{cal} > t_{tab}$ = reject null and accept alternative hypothesis, vice-versa

Results and Discussions

Respondents level of adoption of improved spawning technologies

The respondents of the study were organized into categories based on how they rated their level of adoption of improved spawning technologies. From the results on Table 1, it could be seen that most (65.18%) of the respondents were high adopters of improved spawning technologies. The average adopters constituted 22.32% while low adopters were about 13%. Having a high level of adoption of improved spawning technologies is likely to produce positive and significant results in productivity and income level of the respondents. This result is in agreement with Taiyeet *al.*, (2006) which stated that adoption of improved farm technologies help to enhance farmer's income.

Table 1: Determination of level of adoption of improved spawning technologies

Categorization	Freq.	Percentage
High level of adoption	73	65.18
Average level of adoption	25	22.32
Low level of adoption	14	12.50

Source: Field survey, 2020

Effects of adoption of improved spawning technologies on income of farmers

Table 2 shows the income range of the farmers who adopted improved spawning technologies and those who did not. Among the adopters, most (28.57%) of the farmers earned between ₦400,000 – ₦499,000. While most (29.46%) of the non-adopters earned between ₦200,000 – ₦299,000. The average income of the adopters and non – adopters of improved spawning technologies was ₦347,321.43 and ₦232,535.71 respectively. The difference was ₦114,785.72 in favour of the adopters of the spawning technologies. The result implies that adopting improved spawning technologies goes a long way in improving the quantity (both in size and number) and income of the farmers. The reports of Katungi and Akankwasa (2008) confirmed this finding that farmers who adopt modern agricultural technologies are bound to experience improvement in their farm productivity and income.

Table 2: Income range of respondents' adoption of improved spawning technologies

Income Range (₦'000)	Income Range of Adopters			Income Range of non-Adopters		
	Freq.	%	Mean	Freq.	%	Mean
< 100	9	8.04		21	18.75	
100 – 199	11	9.82		28	25.00	
200 – 299	18	16.07		33	29.46	
300 – 399	26	23.21		14	12.50	
400 – 499	32	28.57		11	9.82	
500 and above	16	14.29	347,321.43	5	4.46	232,535.71

Source: Field survey; 2020; Difference in income = 114,785.72

Constraints plaguing the adoption of improved spawning technologies

Table 3 shows the reasons for respondents' non-adoption of improved spawning technologies. The constraints perceived by the respondents to constitute serious limitations are ranked in the order of their mean weight values. In the light of this, high labour cost (mean = 3.72) was the most serious constraint. Following this is lack of funds (mean = 3.11). Through personal communication, the respondents pointed out that the fish specialists who carry out the process/technology demands so much and many of them have not been able to up with the cost demand due to their poverty level. The third constraint is the scarcity of trained manpower (mean = 3.02). This is a serious problem as spelt out (through personal communication with the respondents) because those endowed with the technology are few, and even at that they still feel reluctant to share the knowledge with other interested persons that are yet in the know. The low number of the trained personnel's endowed with the technologies accounts for why the monetary demands to do the job is high.

Complexity of the process of carrying out improved spawning technologies (mean = 2.95) and incompatibility of the technologies with the culture, norms and tradition of the people (mean = 2.85) were respectively the 4th and 5th serious constraints limiting adoption of improved fish spawning technologies. Ekong (2003) agreed with this finding. The author identified complexity of the process of impacting innovation and incompatibility of innovation with the people's existing values, norms and past experiences as factors influencing adoption of innovation.

Table 3: Constraints limiting the adoption of improved spawning technologies

Limiting factors	Mean	Standard Deviation	Rank
Fear and anxiety	1.82	0.84	9
Lack of funds	3.11*	0.13	2
Scarcity of trained manpower	3.02*	0.58	3
High labour cost	3.72*	0.61	1
Complexity of tech.	2.95*	0.67	4
Chances of success	1.99	0.81	8
Incompatibility with culture, norms and tradition	2.83*	0.41	5
Habit	2.03	0.79	7
Improper packaging of the technology	2.42	0.81	6

Source: Field survey, 2020; Serious constraint (Mean ≥ 2.50)

Effect of adoption of improved fish spawning technologies

The result on Table 6 shows the average income of the fish farmers' adopters and non-adopters of the improved fish spawning technologies. Their mean incomes were ₦347,321.43 and ₦232,535.71 respectively. The difference between the two categories was ₦114,785.72 and it was in favour of the adopters of the technologies. The difference

between the two categories (N114,785.72) was significant at the 5% level. The reason for this conclusion is that the calculated t – value (18,341) was greater than the tabulated t – value (1.645) at the 5% level. On this ground, the null hypothesis was rejected while the alternative was accepted. It thus states: there is significant difference in farm income between adopters and non-adopters of improved spawning technologies. The result thus suggests that the adoption of improved fish spawning technologies enhances farmers’ productivity and income. Confirming this assertion, Taiye *et al.*, (2006) advanced that adoption of improved innovation has a positive role in boosting farmers’ productivity and farm income.

Table 6: Effect of adoption of improved fish spawning technologies (t - test)

Adoption Status	N	Mean Income (₦)	Difference (₦)	t - value
- Adopters of improved fish spawning technologies.	112	347,321.43		
- Non-Adopters of improved fish spawning technologies.	112	232,535.71	114,785.72	18.341*

*Significant at the 5% level (Critical level at 5% level = 1.645)

Conclusion

The findings of this study have shown that most (65.18%) of the farmers were high adopters of improved fish spawning technologies and this translated into having a positive effect on the income of the farmers. This is evidenced on the average income of the adopters (N347,321.43) of the technologies which was quite much more than the average income of the non-adopters (N232,535.71). The difference in the average farm income of the adopters and non-adopters’ categories was N114,785.72 and it was significant at the 5% level. Also, this difference was in favour of the adopters of the technologies. Suffice to say that adoption of the agricultural innovations have positively impacted on the farmers farm income. The average income would have been higher if not for many constraints that plagued many other farmers, thus discouraging them from adopting the improved fish spawning technologies.

Recommendations

However, based on findings of the study the following recommendations were advanced;

- The economic strength of many of the farmers was low. This was expressed by the respondents as a serious constraint through lack of funds. This problem could be brought under check by encouraging the farmers into groups from where they could easily source for funds (via loans). In addition, the farmers that are potentially in need of funds can be given loans by the government to help ameliorate this problem.
- Also, in line with government’s plan to impact skills in her citizenry as part of capacity building, there is need for potentially interested persons to be trained on the improved fish spawning technologies. This will help break the jinx and having more number of people in the know of the technologies and then have more farmers reached, taught and encouraged to adopted the spawning technologies, and;
- There is also a need for the people to be re-oriented and sensitized by the agencies of government on the fact that the products of improved fish spawning technologies have nothing to do with the people’s culture, norms and tradition. Once this is done and able to yield results, more farmers would be seen to adopting the technologies and have more fish produced and realized higher income.

References:

- Africa women championship. (2006). AWC *Special Sourenir*, 5th edition of the championship hold in Delta State, Nigeria. A special publication of the Delta Sports organizing committee of the championship. PP. 10-19.
- Ekong, E.E. (2003). An Introduction to Rural Sociology. Dove Educational Publishers, Uyo, Nigeria. PP. 271 - 282
- Esobhawan, A. O. and Ogundele, S. L. (2011). Cost and returns analysis and the problems affecting artisanal fishing business in Esan South Local Government Area of Edo State, Nigeria. *The Nigerian Journal of Agriculture and Forestry*. 3(1): 109 – 126
- Katungi, E. and Akankwasa, A (2008). Community based organizations and their effect on the adoption of agricultural technologies in Uganda: a case study of Banana (*Musasp*) pest management technology, *National Banana Research Program, Uganda*. PP 719 - 726
- Madukwe, M. C. (2004). Multivariate analysis for agricultural extension research. In: T. A. Olowu, (Ed.) *Research Methods in Agricultural Extension*. Agricultural Extension Society of Nigeria (AESON). PP. 206 – 235.
- Nigeria Population Commission (NPC) of Nigeria (2016). Bureau of Statistics (web). Retrieved at: <http://www.citypopulation.de>php.ni.....> 5th February, 2019

- F. Adedoyin (ed). *Agricultural Extension in Nigeria*, Agricultural Extension Society of Nigeria, Illorin. PP. 220-226
- Olagunju, F.I., Adesiyun, I.O. and Ezekiel, A.A. (2007). Economic viability of catfish production in Oyo State, Nigeria. *Journal of Human Ecology*. 21(2): 12 - 24
- Taiye, O.F., Adebola, O.A. and Adebayo, E.K. (2006). Social activities and socio –economic state of rural farmers cultivating improved maize in kaduna State, Nigeria. *Global Approaches to Extension Practice*. 2(1): 29-36.

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Transfer and Adoption of Plastic Fish Pond Technology for Improved Fish Production in Magbon-Alade Community Area of Ibeju-Lekki Lagos State, Nigeria

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Abstract

Agricultural extension has the potential to achieve a revolution in food security through a participatory approach involving all stakeholders including the farmers. From time past, farmers have found the introduction of new ideas, technology and innovation strange to them due to their beliefs and cultural values. This study assessed the adoption of fish farming technologies in Magbon-Alade community in Ibeju-Lekki, Local Government Area of Lagos State, Nigeria. The technology introduced to the community was plastic fish tanks for fish production so as to help in boosting food productivity, food sustainability and reduce unemployment especially among the youths in the community. A total of 120 structured questionnaires were distributed to gather relevant research data. The data generated from the study were analyzed with descriptive statistics. The socio-economic results showed that 58.33% of the respondents were males, and were between the ages of 30 –39 years. Majority (64.17%) were married, 87.50% had formal education. In addition, most of the respondents (45.00%) practiced full time fishing and were also involved in fish farming and fish related activities (33.33%). Earthen ponds is the major (70.84%) culture systems being practised by the respondents in the study area. Most of the respondents (66.67%) accepted the introduction of plastic tanks, 25.00% rejected it, while 8.33% were indifferent. Moreover, inadequate capital, high cost of feed, lack of space to keep the tanks and to discharge the waste water were the major constraints to the adoption of plastic tanks technologies in this area. It was recommended that intervention programmes should be implemented to ensure that farmers adopt technologies through subsidy of aquaculture inputs.

Keywords: Agricultural Extension, Ibeju-Lekki, Plastic fish tank, farmers, Technology adoption.

Introduction

Aquaculture production in Nigeria has increased tremendously in recent times and this seems to be a step forward towards improving fish production in the country. Despite increase in fish production through aquaculture, Nigeria still ranks among the largest importer of fish because the local demand is greater than the production. It has been observed that Nigeria spends about N50 billion on fish importation annually due to inadequacy in the fish production level (Olatunji *et al.*, 2005). There have been concerted efforts in development of technologies for increased aquaculture production in recent years. To achieve this, agricultural extension agents are constantly engaged in the transfer of developed farming technologies to farmers for adoption so as to enhance their productivity (Olatunji *et al.*, 2005). Ekong (2010) explained that adoption is a decision making process which involves a number of stages. According to Olatunji (2005), the steps involved in the traditional adoption process model are: Evaluation, Trial and Adoption (AIETA). Farmers may not adopt innovation because of lack of awareness, ignorance about the benefits of recommended innovation, lack of required resources or negative attitude to extension recommendations. Jibowu (1992) also noted the characteristics of the innovation and those of the farmers are important in innovation decision process of farmers and their overall adoption pattern.

Agricultural scientists by training and tradition believe that new technologies drive agricultural development if adopted. Research findings are passed through transformative and communicative stages and finally result in improved production. (Adewuyi *et al.*, 2010). The roles of new fish technology are to simplify and make fish production more effective and efficient. It is therefore pertinent to investigate the extent to which fish farming technologies have been transferred to farmers and the extent to which the technology end-users have taken advantage of these technologies. The purpose of this research deals with aquaculture as a means to better livelihood using the technology of plastic tanks to help boost and improve economic and social conditions in some fishing communities. Magbon -Alade, is an important fishing community in Ibeju-Lekki Local Government Area of Lagos State. Hence, the objectives of this study was to carry out (On-Farm Adaptive Research), training of beneficiaries and the introduction of plastic fish tanks as a technology to help in boosting fish production in the community.

Methodology

The study was carried out at Magbon-Alade, a fishing community in Ibeju-Lekki Local Government Area of Lagos State, Nigeria, where majority of the people are into fishing activities. Structured questionnaires were distributed to 120 respondents to determine their socio economic characteristics such as age, educational status, gender and professional status. Also, vital information which includes culture systems being practised by the respondents, rate of adoption and constraints to the adoption of plastic tanks were elicited from the members of the community. Men and women were selected from the community by the community leaders alongside the agricultural science teachers of model college school. The study area was divided into two, which are the community itself and the community school that has both junior and secondary sections. The students involved in the extension programme offer Agricultural Science and Fisheries as subjects; while the community representatives consist of artisanal fishers, fish farmers, fish processors, and fish mongers. Data was analysed using descriptive statistics

Results

The socio- economic characteristics of the respondents are presented in Table 1, out of 120 respondents, 58.33% were found to be males while 41.67% were females. Age is an important socio-economic characteristic because it affects productivity and output. It was obtained from the survey that most (33.33%) of the respondents' ages were between 30-39 years, 25.00% were between 20-29 years and 40-49 years, 12.50% were between 50-59 years, while 4.17% were above 60 years. A larger proportion of the respondents (64.17%) were married, 25.83% were single, while 5.83% were divorced. This implies that majority of the fisher folks shoulder a lot of family responsibilities. The respondents who had primary school accounted for 33.33%, 50.00% had secondary education, 4.17% had tertiary education, while the remaining 12.50% had no formal education. From the survey, 45.00% of the respondent's practice fishing as full time, while 33.33 % were involved in fish farming and fisheries related activities. The culture systems being used by the respondents are presented in Table 2. Earthen ponds accounted for the highest value (70.84%), while cage culture recorded the lowest value (0.83%). However, utilization of plastic tanks was not common. The rate of adoption of plastic tanks (Table 3), indicated that majority (66.67%) of the respondents accepted to use plastic tanks to rear their fish, 25.00% refused, while, 8.33% were indifferent. Respondent's constraints to the adoption of plastic tanks are shown in Table 4. Inadequate facilities accounted for the highest (65.00%) constraints faced by the respondents in the study area; this was followed by high cost of feeds (29.17%), lack of space to keep the tanks and to discharge the waste water recorded the values of 8.33% and 7.50% respectfully.

Table 1: Socio-Economic Characteristics of Respondents

Socio-Economic Characteristics		Frequency	Percentage
Gender	Male	70	58.33
	Female	50	41.67
	Total	120	100
Age	20-29 years	30	25.00
	30-39 years	40	33.33
	40-49 years	30	25.00
	50-59 years	15	12.50
	Above 60 years	5	4.17
	Total	120	100
Marital Status	Married	77	64.17
	Single	31	25.83
	Widow/Widower	5	4.17
	Divorced	7	5.83
	Total	120	100
Level of Education	Primary	40	33.33
	Secondary	60	50.00
	Tertiary	5	4.17
	No formal Education	15	12.50
	Total	120	100
Occupation	Fishing	54	45.00
	Fish Farming/ Processing/Marketing	40	33.33
	Artisans	10	8.33

Civil Servant	4	3.33
Petty Trading	7	5.83
Private Company	5	4.17
Total	120	100

Table 2: Culture Systems Practised by the Respondents

Culture Systems	Frequency	Percentage (%)
Earthen Ponds	85	70.84
Concrete Tanks	3	2.50
Plastic Tanks	0	0.00
Cage	1	0.83
None	31	25.83
Total	120	100

Source: Field survey, 2020

Table 3: Distribution of Respondents Rate of Adoption

Adoption Rate	Frequency	Percentage
Reject	30	25.00
Accept	80	66.67
Indifferent	10	8.33
Total	120	100

Source: Field survey, 2020.

Table 4: Fish Farmers Constraints to Adoption of Plastic Tanks

Constraints	Frequency	Percentage (%)
Inadequate capital/High cost	65.00	54.16
High cost of feeds	35.00	29.17
High fingerlings cost	1.00	0.83
Lack of Space to keep the tanks	10.00	8.33
Lack of Space to discharge waste water	9.00	7.50
Total	120.00	100.00

Source: Field survey, 2020.

Discussion

It has been noted that people do not just adopt a technology because it is available to them. Even when the technology is available and appropriate, some personal and socio-cultural factors peculiar to the respondents influence their decision to adopt or not (Cliffe *et al.*, 2011). In this study some of the socio-economic characteristics of the respondents in the study area were identified, and presented in Table 1. The male significantly dominated the study area with a proportion of 58.33%. This supports the findings of Aphunu and Agwu (2014); and Adewuyi, *et al.* (2010), with the latter reporting male domination in fish farming due to the attendant drudgery, while women were more involved in fish processing. Most (33.33%) of the respondents' ages were between 30-39 years, 25.00% were between 20-29 years and 40-49 years. This is in line with the findings of Aphunu and Agwu (2014) which showed that fish farmers were young, agile and able bodied rather than old and inactive. The implication of this is that fish protein needs could be met by this active group of fish farmers. These are youthful ages which represent the economic active stage in a society. However, studies have shown that middle age populace are more inclined to adoption of innovation (Cliffe *et al.*, 2011).

Most of the respondents as shown in Table 1 were literate with primary, secondary or tertiary educational attainment. The results from this work which indicates that the fisher folks were literate, and are able to adjust to new situations as literate level has been found to influence adoption and with literate people easily tuned to new techniques (Imoh and Essien, 2005). According to Rahji (2003), high literacy level will not only encourage people from adopting new technologies, but also make it easier for such people to understand and evaluate information on new techniques of fish farming.

The implication of this is that adoption of modern technologies can be accelerated, since level of education is known to be influential in the adoption decision of farmer (Olatunji *et al.*, 2005). Most of the respondents are involved in fishing, fish farming and fish related activities, this result agrees with the findings of Akinrotimi *et al.* (2011) who observed the same results in some coastal communities of Niger Delta. Fishing activities, aquaculture, processing, and trading are peculiar to people living coastal areas; they derived their livelihoods from these activities. In the study area, most of the fish farmers utilized earthen ponds to culture their fish. This result agrees with the report of Akinrotimi *et al.* (2010), who reported the same trend in some coastal communities of Rivers State. The finding of this study indicates that the people were more knowledgeable about earthen pond culture as against concrete / plastic tank culture systems. They believed that it was easier and cheaper to construct and manage earthen ponds than concrete ponds. This was because people helped each other to dig and construct the ponds due to cultural bonding and the believe that earthen ponds are cheaper and easier to maintain than concrete ponds, though most of the earthen ponds have closed down due to attacks by predators and poaching from humans. The findings in the secondary school at Magbon Alade shows that they had an existing earthen pond which has ceased to function due to attacks by predators and theft by humans which is usually associated with earthen ponds because of its distant locations. This contradicts the findings of Olaoye *et al.* (2014), who found that fish farmers prefer more of concrete tanks as against earthen ponds. However, the findings of Olaoye, *et al.* (2007) and Olaoye, (2010) revealed that the adoption of culture in concrete tanks was mainly prominent in urban areas as the adoption of earthen ponds were more in the rural areas.

The level of adoption of the plastic tanks was appreciable in the study area. On the whole, the level of adoption in the study area was a little bit above the average. Hence, a more vigorous activity of technology transfer should be embarked upon in the study area, even as Ruttam (1997) had asserted that adoption of technologies and their sustained use would depend on efficiency of technology development, dissemination and follow-up procedures. In this study, inadequate capital and high costs of feed were the major constraints to the adoption of fish farming technologies in the study area. This corroborates with the findings of Akirotimi (2011) in similar study conducted in coastal communities of Rivers State. After the On-Farm Adaptive Research and the training of beneficiaries, members of Magbon-Alade community and Model College were provided with some inputs such as plastic tanks, fingerlings of *Clarias gariepinus* and fish feed. Feedback from respondents after one year of presentation of plastic tank showed that they continued using the plastic fish tank for fish production. This shows that the new technology was adopted by the people which were not their initial practices. Majority indicated that their yields have increased as a result of adoption of improved fish production technologies such as improved NIOMR-WAAPP smoking kiln which was earlier adopted by the community through the Nigerian Institute for Oceanography and Marine Research (NIOMR), Lagos initiative. (NIOMR Field survey, 2015).

Conclusion and Recommendations

The study assessed adoption utilization of plastic tanks as a means of fish farming technologies in Magbon-Alade community in Ibeju-Lekki Local Government of Lagos State, Nigeria. Based on these findings, it was recommended: That the Federal Government should subsidize the price of fish feeds and provide credit facilities to encourage local production of fish in the study area.



Plate 1: Plastic Fish Tanks

Photo credit, Priscilla Eitokpah. Magbon-alade community

Recommendations

1. Although artisanal fishing is predominant in the study area, fishermen should also be encouraged to practise fish culture to augment fish production in Nigeria.
2. Farmers should be encouraged to adopt plastic tanks culture method because this technology can easily be monitored.
3. Extension and aquaculture experts should regularly visit rural communities to learn from and educate the members of the community, on how they can diversify their livelihoods by adopting fish farming techniques such as the use of plastic ponds for easy monitoring, reduced security risks and year-round production of fish.

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References

- Adewuyi, S. A., Phillip, B. B., Ayinde, I. A., and Akerele, D. (2010). Analysis of profitability of fish farming in Ogun state, Nigeria. *Journal of Human Ecology*, 31(3): 179-184.
- Akinrotimi, O.A., Edun, O.M., Uka, A., Ogori, K.T., Mokayi, P.K., & Owhonda, K.N. (2010). Public Perception of Mudskipper consumption in some fishing communities of Rivers State. In: Ansa, E.J., Fashina – Bombata H.A. and Ndimele, P.E. (Eds) Proceeding of the 25th Annual Conference and fair of the fisheries Society of Nigeria. 25-29th October, 2010. Badagry Lagos, Nigeria.
- Akinrotimi, O.A. (2011). Issues limiting the expansion of brackish water aquaculture in the coastal area of Niger Delta. Pp. 169 – 178. In: R.J. Kolo and A.M. Oire (eds). Proceedings of the 26th Annual Conference of Fisheries Society of Nigeria (FISON), Federal University of Technology, Minna, Niger State, Nigeria. 28th November – 2nd December, 2011.
- Akinrotimi, O.A., Abu, O.M.G., & Aranyo, A.A. (2011). Transforming aquaculture from subsistence to commercial level for sustainable development in Niger Delta Region of Nigeria. *Journal of Agriculture and Social Research*, 11(2), 22 – 33
- Aphunu, A., and Agwu, A. E. (2014). Adoption of improved aquaculture management practices by cluster fish farmers in Delta state, Nigeria. *Journal of Agricultural Extension*, 18(2), 37-43.
- Cliffe, P.T., Akinrotimi, O.A., & Ibemere, I.F. (2011). Promoting women participation in aquaculture as a viable tool for poverty alleviation in the rural areas of Nigeria. *Global Approaches to Extension Practice*, 7(1), 98-105.
- Ekong, E.E. (2010) Rural Sociology -Third Edition. Uyo: DOVE Educational Publishers. pp.438.
- Field survey, Nigerian Institute for Oceanography and Marine Research (NIOMR). 2015
- Jibowo, A.A. (1992) Rural Social Change. In A.A Jibowo (Ed) *Essentials of Rural Sociology (Second Edition)*. Abeokuta: Cobemi Sodipo Press. pp 228.
- Olaoye, O. J., Adekoya, B.B., Ezri, G.N.O., Omoyinmi, G.A.K. and Ayansanwo, O. (2007). Fish hatchery production trends in Ogun State. *Journal of field aquatic studies-Aquafield*, 3: 29-40
- Olaoye, O. (2010). Why Policies Fail in Nigeria: An Evaluation of Agriculture Policies made from 1972-1985. *International Journal of Sustainable Development*, 1(1): 84-86
- Olaoye O. J., Adegbite D.A. and Oluwalana E.O. (2014). Comparative evaluation of economic benefits of earthen fish ponds and concrete tanks in aquaculture enterprises in Oyo state Nigeria. *Croatian journal of fisheries :Ribarstvo* 72 (3) 107-117.
- Olatunji, S.O. (2005) *Effective Teaching and Extension of Agriculture in the Tropics*. Kaduna: Zero Point International Publications. pp 288.
- Rahji, M.A.Y. (2003). An analysis of the production efficiency of broiler firms in Ibadan Area of Oyo State, Nigeria. *Nigerian Journal of Animal Science*, 6 (2) : 103-110.
- Ruttam, A. A. (1997) *Fish Smoking in: Fish Processing Technology in the Tropics*. Published by National Institute for Fresh Water Fisheries Research (NIFFR), New Bussa Nigeria. pp 153- 192.
- Umoh, A.N. and Essien, M.U. (2005) Adoption of Improved Cassava Varieties Among Small Scale Farmers in Ikot Ekpen Agricultural Zone of Akwa Ibom State In proceedings of the 39th Annual Conference of the Agricultural Society of Nigeria pp 1-4

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Assessment of Fisheries Livelihood and Rural Infrastructure in Post-Resettlement Fishing Communities in Kainji Lake Basin

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Abstract

Rural infrastructure plays important role in poverty alleviation in sustainable fisheries livelihood in fishing communities. This informed the study of rural infrastructure and fisheries livelihood in post-resettlement of Sabon Gida fishing community in Kainji Lake basin, Nigeria. Multistage sampling technique was deployed to purposively select the community and randomly sampled 117 respondents. Primary data was generated through semi structured interview schedule and data was analyzed descriptively. Result established that after post-resettlement, respondents still engages more in capture fisheries livelihood activities on fishing, fish marketing, net repairing and fish processing, but discontinued with aquaculture practice on table size fish farming. Interestingly, post-resettled community have access to 12 new rural infrastructures on education, health, religion, sport, security, and water which was provided by a private organization named Mainstream Foundation, except communication by mobile phone service providers. Active infrastructures put to use by the community were Mosque (99.1%), School (98.3%), Road (95.7%), Health Center (90.6%), Football Field (86.3%), Market (73.0%), Solar Powered Borehole (41.0%), Tube well (30.8%), police station (30%) and partial GSM network (25.6%). Identified challenges in the post-resettlement programme were poor cash compensation, inadequate farm land, erosion and collapse building as well as mismanagement and diversion of cash for other purposes by beneficiaries. Despite existing new model infrastructure, the community has not yet derived expected benefits to improve their wellbeing and livelihood on health facilities, education and borehole due to cultural, religious, economic and technical issues to repair and pay for services. As such, there is need for community sensitization to change old perceptions on male health workers attending to their wives, girl child right to education and youth's skill technical training to repair boreholes, and solar panel to derive expected benefits.

Keywords: Fisheries, rural infrastructure, livelihood, resettlement, Kanji Lake.

Introduction

Rural areas are characterized by poor development, where the majority lives below the poverty line due to limited social services and infrastructure. Amadi (2010) proposed that development can occur when the goods and services and infrastructures are evenly distributed in such a way that the majority of the masses especially those in rural communities can afford to shelter themselves, feed, have a sense of belonging and security. Fishing communities are characterized as one of the poorest of the poor linked to poor rural infrastructure, their vulnerability to economic deprivation with being trapped in a poverty circle. This fact was established in Kainji Lake Basin (KLB) by Tafida (2009) on gross inadequacy of infrastructure facilities in the KLB fishing communities as 86.7% lack tarred road, electricity, and market while 96.7% lack access to financial institutions.

Despite the ugly situation in the fishing communities, fish captured by fishers in poor fishing villages is a rich product whereas fisheries are one of the important sub-sectors of agriculture that makes a significant contribution to the livelihood of people and contributes positively to country's gross domestic product put at 4%. This is confirmed by Mafimisebi and Thompson (2012), that fisheries contribution to the livelihood of the people and nation's economy is significant in terms of employment, income generation, poverty alleviation, and provision of raw materials for industries. Yunawa fishing community was one of the old settled fishing villages under the Auna district in the Kontagora Emirate. Ongoing activities at the Kainji dam which was privatized to the private sector called Mainstream Energy Solutions Limited initiated the idea of Yunawa fishing community resettlement to a new site called Sabon Gari. The relocated villages where fisheries have been their major livelihood include; SabonYunawa, TudunFaila, GadanZare, and Tungan Gare. Olawepo (2006) noted that resettled families in Jebba Lake experienced considerable occupational dislocations and major disruption of the domestic economy particularly those distantly relocated from old places. The issue of fisheries livelihood in Yunawa community can be positive

and benchmark as a model for development only if changes result from an improvement in the status of evacuees, and open them to more opportunities than their former settlement. The above background prompted interest for the study to document likely changes that occur in livelihood and infrastructure before and after resettlement in the community.

The Specific objectives include;

1. Identify the type of resettlement infrastructure
2. Ascertain fisheries livelihood of evacuees
3. Identify challenges of evacuees in the new settlement

Methodology

Sabon Gida community was purposively selected as the resettled fishing community for study. The population of the study is the entire adult men and women in Sabon Gida fishing communities made up as follows; SabonYunawa, TudunFaila, GadanZare, and TunganGarein Auna district, under Kontagora emirate in Magama Local Government Area of Niger State. In absence of secondary data on resettled beneficiaries, a proportional sampling technique was deployed to sample 10% of the men and women who were randomly chosen in the four communities to get 117 as respondents. Primary data was collected from the respondents with a semi-structured questionnaire through face to face interview. Statistical Package for Social Science (SPSS) version 20 was used for the data analysis descriptively.

Results and Discussions

Fisheries Livelihood Activities Engaged Before and After Relocation in the Community

Table 1 presents the fisheries ‘livelihood activities engaged before and after relocation in the community. The finding shows that both fish catch (39.3%) and fish marketing (35%) were the dominant fisheries livelihood activities of the people before and after relocation to the new settlement. Other livelihood activities sustained in the new community on fishery were boat repairs, net repairs, fishing input sales as well as crop and livestock rearing. It indicates that the people engaged in their usual livelihood practices in artisanal fishery due to easy access to the lake for fishing which is less than 2kilometers. The finding corroborated the work of Olawepo (2006) on Jebba Lake that the nearness of fishers and farmers to their formal locations enabled them to return to customary fishing and farming. Unfortunately, respondents’ totally abandoned aquaculture activities on table size, fingerlings, and feed formulation among others after relocation to a new community which was introduced to them under West Africa Agricultural Productivity Programme (WAAPP) as one of the adopted villages by the National Institute for Freshwater Fisheries Research (NIFFR), New Bussa. Discontinuation of aquaculture activities is a setback on the rural economy for additional income for men, women and youths which need to be reintroduced in the new resettlement by addressing the water problems.

Fisheries Livelihoods Activities Engaged Before and After Post Resettlement				
Activities	Before Relocation		After Relocation	
	Frequency	Percentage	Frequency	Percentage
Table size	41	35.0	-	-
Hatchery	18	15.4	-	-
Feed formulation	1	0.9	-	-
Aquaculture input sale	1	0.9	-	-
Fish marketing	57	48.7	19	16.2
Fish processing	20	17.1	8	6.8
Fish transportation	4	3.4	-	-
Fish catch	46	39.3	28	23.9
Boat repair	31	26.5	4	3.4
Net repair	39	33.3	12	10.3
Fishing input sale	2	1.7	-	-
Wild fingerlings	2	1.7	-	-
Gear production	3	2.6	2	1.7
Crop/Animal farming	22	18.8	11	9.4
Trading	4	3.4	6	5.1

Field survey: 2020

Physical infrastructures of Communities

Identified were twelve (12) existing physical infrastructures found in the new fishing community which was not in the old community before as shown in Table 2 cut across health, education, religion, social, security, water, and communication. The new model of rural infrastructure in the community was provided by a private organization named Mainstream Foundation a subsidiary of Mainstream Energy Solutions Limited. The most actively used infrastructures were mosque (99.1%), school (98.3%), road (95.7%) health center (90.6%), football field (86.3%) and market (73.0%). Access to infrastructures empowers the people to the decent worship center, facility to acquire primary school education by enrolling their wards although more boys were currently enrolled than girls, neat water for good health and hygiene as well as a health center for quick treatment of disease and illness. However, there was low enrollment of girl the child in the school and low patronage of health center due to cultural and religious norms of men not seeing or touching women which affects pregnant women from receiving antenatal care due to male health workers. Existing infrastructure, falls into what Olaseni and Alade (2012) categorized as economic, social, and institutional infrastructures such as road, markets, electricity, telecommunication, water supply, sanitation, and sewage. Also, existing infrastructure in the community is a model to emulate towards alleviation of poverty and improve wellbeing in the fishing communities. With the infrastructures, it is expected that respondents' make better usage to enjoy a better life and to improve the standard of living in the new community than before.

Table 2: Physical infrastructures of Communities

Infrastructures	Active		Dormant	
	Frequency	%	Frequency	%
Health center	106	90.6	11	9.4
Borehole	48	41.0	69	59.0
School	115	98.3	2	1.7
Market	86	73.5	31	26.5
Access road	112	95.7	5	4.3
Tube Well	36	30.8	81	69.2
GSM network	30	25.6	87	74.4
Electricity	1	0.9	116	99.1
Public toilet	6	0.9	116	99.1
Football field	101	86.3	16	2.6
Town hall	7	0.9	116	0.0
Mosque	116	99.1	1	0.9

Source: Field Survey, (2020)

Challenges Faced in the New Settlement

Presented in Figure 3 were identified challenges in the new settlement after relocation. Some of the respondents indicated that they were constrained with poor cash compensation (34.2%) excluding the women gender leading to uncompleted buildings, followed by inadequate farmland (23.1%) to engage in crop farming, long distance of almost 2kilometers to kainji lake for fishing (19.7%), collapse building (14.5%) on waterways, and flood and erosion (4.3%). Poor compensation put respondents in difficult financial stress to build low quality houses, discontinue aquaculture practices and lack of land to expand their farming activities on crop farming and livestock rearing. On erosion, flood, and collapse building was due to land topography, poor drainage, poor building materials, and high-speed wind. It shows that implementers had poor planning, mapping, monitoring, and evaluation of the settlement programme. These challenges hamper the communities from deriving maximum benefit from the rural infrastructure to improve their livelihood and well-being as expected. D'souza and Brenda (2020) also support this in their project reports that resettlement can have dramatic impacts on fishing livelihood such as inadequate farmland, decrease diversity, distance to the fishing area, increase the cost of living, damages to livelihood assets

among others. The new settlement needs corrective measures like planting of trees as well as construction proper drainage to channel runoff water.

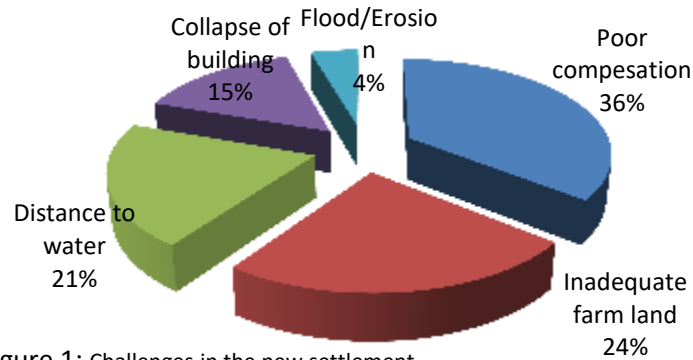


Figure 1: Challenges in the new settlement

Conclusion and Recommendations

The findings of this study revealed that respondents have the better rural infrastructure to improve life in new a community than before which is a model to develop rural villages like fishing communities. However, there is disconnect in some fishery livelihood in the new settlement, low girl child school enrollment, low usage of health facilities by women, damage to infrastructures, and overbearing influence of culture and religion. Identified constraints pose a serious threat to their rural economic livelihood in fisheries. Recommendations include; sensitization of men, women, and youths to ensure proper utilization of the infrastructures, change of mindset on cultural and religious belief on girl child education, and women being treated by male health workers. Also, there is a need to train youths to acquire skills to repair some of the dormant infrastructures for better usage.

References

- Amadi, U. E. (2010). Problems and prospects of community development in Ebonyi State. The department of public administration and local government, university of Nigeria, Nsukka. *International Journal of Developing Societies*, 1 (3).
- Mafimisebi, T. E. and, O.A. Thompson, (2012). Empirical Evidence of Fisheries SubSector's Contribution to the Nigerian Economy. *International Journal of Agricultural Science, Research and Technology*, 2(1):31-35
- D'souzaA. and Brenda P. (2020): Fishing livelihoods and diversifications in the Mekong River Basin in the Context of the Pak Mun Dam, Thailand. Department of resource economics and environmental sociology; University of Alberta, Edmonton, Canada.
- Olawepo, R.A. (2006). Resettlement and Agricultural Change in a Rural Nigerian Environment: The Jebba Scheme Example. *International Journal of Rural Management*, 2(1).58-66
- Olaseni, M. and Alade, W. (2012).Vision 20:2020 and the challenges of infrastructure development in Nigeria. *Journal of Sustainable Development*, Vol.5 (2), 63-66
- Tafida, A. A. An Assessment of Livelihood Diversification as A Strategy for Coping with Poverty among the Artisanal Fishers in Kainji Lake Basin Nigeria" Ph.D. Thesis submitted to Geography Department, Federal University of Technology Yola, 2010; 139

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Effects of Herdsmen and Farmers Clashes on Artisanal Fisheries (A Case Study of Loko and Umaisha Development Areas of Nasarawa State)

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Abstract

This study investigated the effects of herdsmen and farmer's clashes on artisanal fisheries in Loko and Umaisha Development Areas of Nasarawa State. The sample of the study consisted of eighty (80) respondents from Loko and Umaisha Development Areas whom were selected via purposive sampling technique. The questionnaire was used to collect data. Descriptive statistics, pie chart and histogram were used to analyze the data generated from respondents. The findings revealed that the major causes of the conflict were diminishing land resources (50.33%), destruction of crops by cattle and other property and burning of rangelands, Fadama and blockage of stock routes and water points by crop encroachment (49.68% each), increasing rate of cattle rustling which, is often accompanied by violence (49.03%) and inadequacy of grazing resources, due to increasing crop cultivation (47.74%). The social effect of the menace of herdsmen/farmers clashes on artisanal fisheries are decline in household fisheries and resources (67.89%), loss of self-esteem among herdsmen and fishermen (67%), destruction of fishing grounds and other social amenities (65.21%) the decline in quality of the relationship between herdsmen and fishermen (57.17%), reduction in family/personal health of herdsmen/fishermen (51.81%) and loss of lives of both the herdsmen and fishermen (50.92%), while the economic effect of the menace of herdsmen and farmers clashes on artisanal fisheries in the study area are reduction in income of fishermen (100%) decline in yield of fish catch (98.75%), destruction and loss of fishing gears and craft (93.75%) and pollution of the aquatic environment by blood stains and dead animals/human (67.5%). Based on the findings, it was recommended among others that representatives of the host communities (Loko and Umaisha) and herdsmen should be conveyed under a public forum and involved in the decision making and permitted to take part actively in the planning procedure of restoring peace to most of the affected communities.

Keywords: Herdsmen, Farmers clash, Artisanal fisheries, Loko, Umaisha

Introduction

The necessity to provide food of crops and animals, as well as raw materials for industry and export to meet the ever growing demands, has led to both "intensification and extensification" of land use (Nyong and Fiki, 2005). The competition between these two agricultural land user groups, however, has often times turned into a serious manifestation of hostilities and social friction in many parts of Nigeria. The conflicts have demonstrated high potential to exacerbate the insecurity and food crisis particularly in rural communities where most of the conflicts are localized, with overbearing consequences nationwide. Farmer-herdsmen conflict has remained the most preponderant resource-use conflict in Nigeria (Ajuwon, 2004; Fasona and Omojola, 2005).

Pastoralists (herdsmen) move their herds to graze on farmlands belonging to crop farmers and also acquire the feed stuffs produced by crop farmers; farmers on the other hand require from pastoralists protein and dairy products (Shettima and Tar, 2008). According to Monod (1975) the survival of herdsmen is dependent upon their interaction with sedentary people. Thus both farmers and herdsmen depend on each other for water, fodder, land and other resources. The relationship existing between farmers and herdsmen therefore makes conflicts inevitable as competing interest arises over the use of natural resources.

However, according to Okereke (2012) and Bello (2013), the conflicts in most part of Nigeria especially the herdsmen and farmers clash are largely uncalled for. Farmers can no longer farm peacefully because of herdsmen. Fishing is an ancient human traditional activity involving the hunting and gathering of products such as food from water which is an indispensable natural resource on earth (Ita, 1993). Fishing has become a means of satisfying subsistence needs and provides sources of cash income to fishers (Ipinmoroti and Adesina, 2011), as over 98% of fishing communities in Nigeria depend on artisanal fishery and related services for their livelihood, supplying 75%

of the animal protein intake (Akankali and Elenwo, 2015). Most of the artisanal fishermen in Nigeria are farmers who engage in artisanal fishing to support their means of livelihood. Studies conducted by Okereke (2012) and Kasarachi (2016) have shown that, serious conflict erupt between herdsman and farmers leading to loss of lives, valuable properties, destruction of a vast expanse of arable agricultural farmlands thereby posing a serious threat to food security since farmers for fear of attack could no longer go to the arm and harvest their farm produce. These farmers and fishermen are displaced from their places of farming and fishing as a result of farmer's and herdsman's conflicts. It is in the realization of these facts that the research was carried out to determine the effects of herdsman and farmers clash on artisanal fisheries in Loko and Umaisha in Toto Local Government Areas of Nasarawa State.

Research Methodology

Study Areas

Loko is in Nasarawa Local Government Area of Nasarawa State in the middle belt region or North central zone of Nigeria. It is located along the bank of River Benue. The town is a mini-port along the river Benue, for the conveyance of export materials, to the eastern and western parts of Nigeria. The main activities engaged by the inhabitants of Loko town are farming and fishing while Umaisha is situated in the eastern part and 40 km away from Toto LGA Headquarters and 85km from the Federal Capital Territory (FCT) Abuja. Umaisha is an old settlement and has existed since the 14th century and its inhabitants are the Igbiras, referred to here, as the Opanda Kingdom. The Umaishas have potential for fishing and cultural festivals (Yahaya, 2007). The economic activities are largely agrarian with the majority of the people as subsistence farmers who cultivate crops such as rice, okra, melon, cowpea, millet, sesame seeds, sweet potatoes, and a few other crops.



Fig 1: Map of Nasarawa State showing water bodies of Loko and Umaisha
Source: NAGIS (2019)

Sampling Procedure

The sampling frame for this study comprised farmers who are also artisanal fishermen in Loko and Umaisha Development Areas of Nasarawa State. Four (4) fishing villages (Loko, Ogupa, Ayitsa, and Ayele) were purposively selected from Loko Development Area, while four (4) fishing communities namely; Ogbera, Umaisha, Igi, and Ihankpe were selected from Umaisha Development Area based on their participation in farming and fishing. Ten (10) artisanal fishermen were randomly selected from each village making a total of eighty (80) respondents for the study.

Data Collection

Primary data was used for the study. This was collected through the use of a set of questionnaires that were administered to the fish farmers. Data was collected on the socio-economic characteristics of the fishermen, causes of herdsman and farmers clashes in the study areas, social effects of the menace of herdsman and farmers clashes in the study areas and economic effects of the menace of herdsman and farmers clashes in the study areas. One hundred (100) questionnaires were administered but eighty were returned.

Data Analysis

Descriptive statistics such as frequency distribution, mean, percentages, pie chart and bar chart was used to satisfy objectives (i, ii, iii and iv) respectively.

Results

Socio-Economic Characteristics of Respondents

The result of the socio-economic characteristics of the respondents is presented in table 1. From the results, (37.50%) of the fish farmers in the study area were between the ages of 51-60 years, (28.75%) were between the ages of 40 – 50 years, (21.25%), were between the ages of 29 – 39 years, while the lowest (12.50%), were between the ages of 18-28 years.

Table 1: Socio-Economic Characteristics of Respondents

Variables	Response	Frequency	Percentage (%)
Age (years)	18-28	10	12.50
	29-39	17	21.25
	40- 50	23	28.75
	51-60	30	37.50

Source: Field survey, 2019;

Causes of Farmers/Herders Clashes

Figure 2 presents the results of causes of farmers/herders clashes in the study area. From the results, it showed that the major causes of herdsman and farmers clashes were diminishing land resources (50.33%), destruction of crops by cattle and other property and burning of rangelands, fadama and blockage of stock routes and water points by crop encroachment (49.68% each), increasing rate of cattle rustling which, is often accompanied by violence (49.03%), the inadequacy of grazing resources, due to increasing crop cultivation (47.74%), inequitable access to land and non-recognition of rights of persons (39.35%) and antagonistic perceptions and beliefs among farmers and herdsman with (34.84%) respectively.

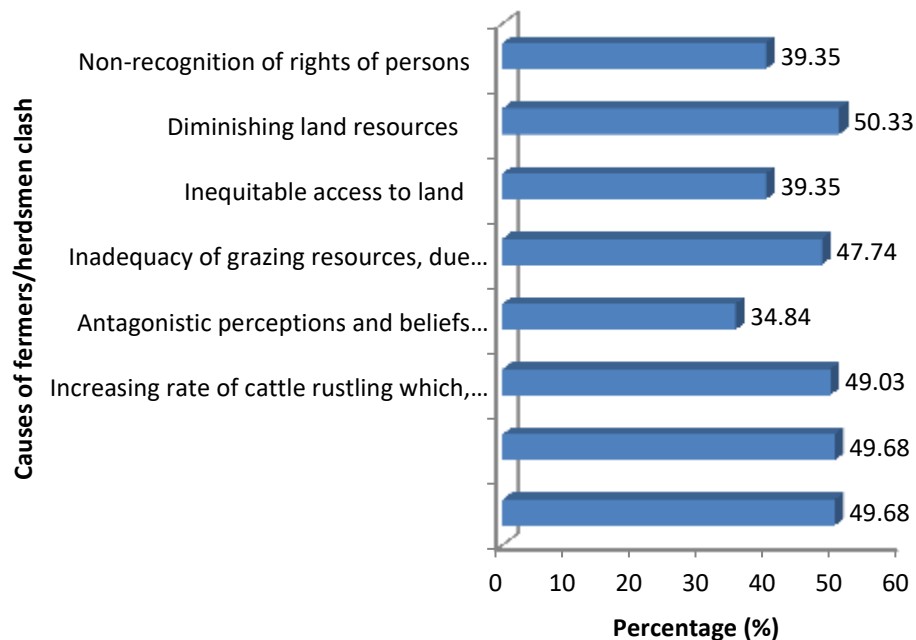


Fig 2: Bar chart showing the causes of farmers/herders clashes

*Source: Field survey, 2019; *Multiple response were allowed*

Social Effect of Menace of Herdsmen/Farmers Clashes on Artisanal Fisheries

Figure 3 presents the results of the social effects of the menace of herdsmen/farmers clashes on artisanal fisheries in the study areas. The result revealed that the major social effect of the menace of herdsmen/farmers clashes was decline in household fisheries and resources (67.89%), loss of self-esteem among herdsmen and fishermen (67%), destruction of fishing grounds and other social amenities (65.21%), decline in quality of the relationship between herdsmen and fishermen (57.17%), reduction in family/personal health of herdsmen/fishermen (51.81%) and loss of lives of both the herdsmen and fishermen with human life at (50.92%) respectively.

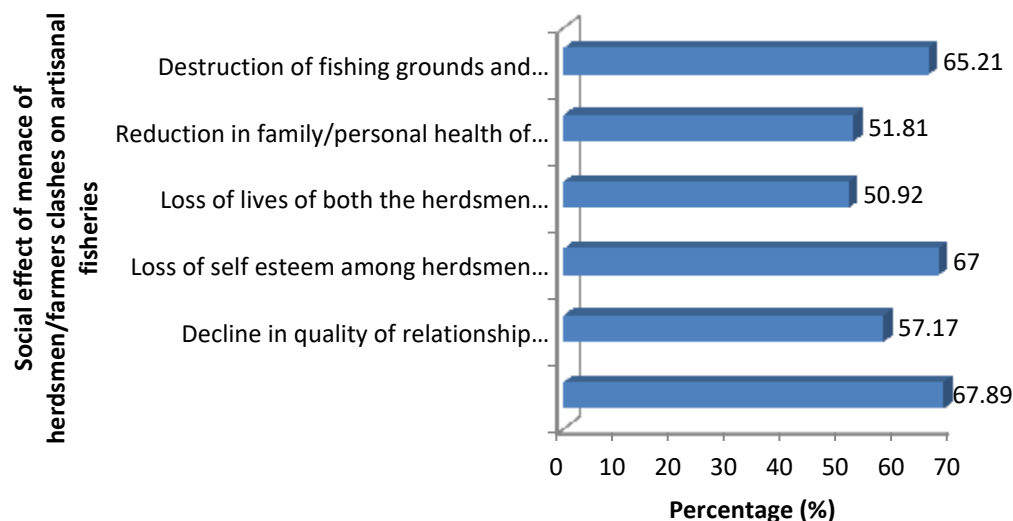


Fig 3: Bar chart showing the result of social effect of menace of herdsmen/farmers clashes on artisanal fisheries

Source: Field survey, 2019; *Multiple response were allowed

Economic Effect of Menace of Herdsmen/Farmers Clashes on Artisanal Fisheries

The result of economic effects of the menace of herdsmen/farmers clashes on artisanal fisheries in the study area are presented in figure 4. The result reveals that the major economic effect of the menace of herdsmen/farmers clashes on artisanal fisheries in the study area is reduction in the income of fishermen which was represented by 100% followed by a decline in yield of fish catch (98.75%), destruction, and loss of fishing gears and craft (93.75%) and pollution of the aquatic environment by blood stains and dead animals/human (67.5%).

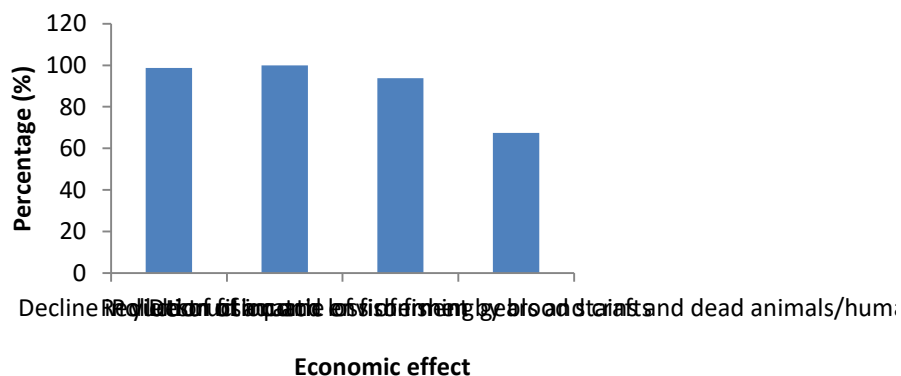


Fig 4: Bar chart showing the result of economic effect of menace of herdsmen/farmers clashes on artisanal fisheries

Source: Field survey, 2019; *Multiple response were allowed

Discussion

The major causes of herdsman and farmers clashes in the study area are diminishing land resources, destruction of crops by cattle and other property and burning of rangelands, fadama and blockage of stock routes and water points by crop encroachment, increasing rate of cattle rustling which, is often accompanied by violence and inadequacy of grazing resources, due to increasing crop cultivation. This result agrees with the findings of Ingawa *et al.* (1999) reported that the key underlying causes of farmer-herdsmen conflict in Nigeria are: decline in internal discipline and social cohesion, as the adherence to the traditional rules regarding, grazing periods, and the authority of the traditional rulers is breaking down. In support of the above claim, Okereke (2012) and Bello (2013) listed the causes of the conflict to include theft of cattle, destruction of crops, rape of women, and indiscriminate bush burning.

The findings of this study also revealed that the major social effect of the menace of herdsman/farmers clashes in the study is decline in household fisheries and resources, loss of self-esteem among herdsman and fishermen, destruction of fishing grounds and other social amenities, the decline in quality of the relationship between herdsman and fishermen, reduction in family/personal health of herdsman/fishermen. The major economic effects of the menace of herdsman/farmers clashes in the study area are reduction in income of fishermen, the decline in yield of fish catch, destruction and loss of fishing gears and crafts, and pollution of aquatic environment by blood stains and dead animals/human. The result agrees with the findings of Nweze (2005) and Bello (2013). In the present study, the result —confirms the positions of other researchers such as Ajayi and Allagenyi (2001), Johnson and Johnson (2002), and Daniels (2006) who stated in their separate studies that family instability and intense frustration are negative consequences of job-related conflicts. Both artisanal fishermen, farmers and herdsman suffered several negative socio-psychological consequences relating to their respective family lives. It could be because whatever happens at work could affect what happens at home. According to Potter (1995), it is hardly possible to find a frustrated person at work that is energized at home. These effects were, however, found to be more pronounced among the farmers than herdsman, probably due to the fact that farmers suffered more losses than herdsman.

Conclusion

Farmers/herdsman clashes have social and economic effects on both farmers and herdsman in Loko and Umaisha development areas of Nasarawa State. As observed in this study, the causes of the conflict are diminishing land resources, destruction of crops by cattle and other property and burning of rangelands, fadama and blockage of stock routes and water points by crop encroachment, increasing rate of cattle rustling which, is often accompanied by violence and inadequacy of grazing resources, due to increasing crop cultivation. The social effect of the menace of herdsman/farmers in the study areas are decline in household fisheries and resources, loss of self-esteem among herdsman and fishermen, destruction of fishing grounds and other social amenities, the decline in quality of the relationship between herdsman and fishermen, reduction in family/personal health of herdsman/fishermen while the economic effect of the menace of herdsman/farmers clashes on artisanal fisheries in the study areas are reduction in income of fishermen, the decline in yield of fish catch, destruction and loss of fishing gears and craft and pollution of the aquatic environment by blood stains and dead animals/human.

Recommendations

- Representatives of the Loko and Umaisha communities and herdsman should be conveyed under a public forum and involved in the decision making and permitted to take part actively in the planning procedure of restoring peace to most of the affected communities.
- Participatory planning process that involves all stakeholders (herdsman and farmers) in the dispute resolution mechanism should be adopted to prevent a one-sided judgement.
- Ranching method of cattle rearing should be adopted at rearing locations across the country while the herdsman should be given needed training for effective and efficient management of the ranch.
- There is a need for proper orientation and re-orientation of farmers and herdsman in Loko and Umaisha development areas of Nasarawa State on the essence of social interaction irrespective of the religious and ethics background.
- Government at both Federal and State levels should be firm and fair in its conflict resolution methods and implementation of decisions.
- Effort should be geared towards institutions carrying out research that are technologically driven to create land management for farming, fishing and grazing.

References

- Ajayi, A. R. and Allagenyi, L. D. (2001). Organizational Factors in Sustainable Extension Service Delivery in Nigeria: The Effects of Job-related Stress on Organization Involvement and Quality of Family-life of Extension Agents of Benue State Agricultural Development Programme. *Journal of Agricultural Extension*, Vol. 5, pp.9-21
- Ajuwon, S. S. (2004). Case Study: Conflict in Fadama Communities. In *Managing Conflict in Community Development*. Session 5, Community Driven Development.
- Akankali, J.A. and Elenwo, E.I. (2015). "The Atmospheric Input of Species to the World Oceans", *Joint Experts on the Scientific Aspects of Marine Pollution*, Vol. 38 No 1, pp. 111.
- Bello, A.S. (2013). Herdsmen and Farmers Conflicts in North-Eastern Nigeria: Causes, Repercussions and Resolutions. *Academic Journal of Interdisciplinary Studies*, 2(5): 29-139.
- Daniels, A. M. (2006). Farming, Ranching and Stress: It's a Family Issue. *Extension Extra*, ExEx 14058. South Dakota State University Cooperative Extension. Pp. 1-4
- Fasona, M. J. and Omojola, A. S. (2005). "Climate Change, Human Security and Communal Clashes in Nigeria." Paper at International Workshop in Human Security and Climate change, Holmen Fjord Hotel, Oslo Oct. 21-23, 2005.
- Ingawa, S.A; Ega, L.A; and Erhabor, P. O. (1999). Farmer-Pastoralist Conflict in Core-states of the National Fadama Project, FACU, Abuja.
- Ipinmoroti, M.O. and Adesina, B.T. (2011). "Fisheries and Aquaculture in Rural Development", in S. F. Adedoyin (ed). *Rural Agricultural and Environmental Sociology in Nigeria*. Nigerian Rural Sociology Association (NRSA). Ibadan, Andkolad Publishers Ltd. Pp 228- 38.
- Ita, E .O. (1993). Inland Fishery Resources of Nigeria. *Central Institute of Freshwater Aquaculture Occasional Paper*, 20: 120-126.
- Johnson, D. W. and Johnson, F. P. (2000). *Joining Together: Group Theory and Group Skills* (7th Edition), Boston, Allyn, and Bacon.
- Kasarachi, N. P. (2016). Institutionalizing peace education for sustainable development in public secondary schools in Delta State. *Niger Delta Journal of Education*, 8(1), 194-196.
- Monod, T. H. (1975). *Pastoralism in Tropical Africa*. Oxford University Press
- Nweze, N.J. (2005). Minimizing farmer-herder conflicts in Fadama Areas through Local Development Plans: Implications for increased crop/livestock productivity in Nigeria. Paper presented at the 30th Annual Conference of the Nigerian Society for Animal Production, held 20th – 24th March.
- Nyong, A and Fiki, C. (2005). "Droughts-Related Conflicts, Management and Resolution in the West African Sahel." Human Security and Climate change International Workshop. Oslo; GECHS, CICERO and PR20.
- Okereke, D. (2012). The remote immediate cause of crimes, insecurity, terrorism and instability in Nigeria and solution. Retrieved from <http://www.nairand.com/1027585/remote-immediatecauses-crimes> on January 19th, 2018
- Potter, B.A. (1995). *Preventing Job Burnout*, 2nd Edition, Crisp Learning Publishers, UK. Shettima, A. G., and Tar, U. A. (2008). Farmer-Pastoralist Conflict in West Africa: Exploring the Causes and Consequences. *Information, Society and Justice*, 1,2, 163–184. doi:10.3734/isj.2008.1205.
- Yahaya, A. (2007). "Loko calls for speedy development of Loko DA". Nasarawa Publishing Company Limited. Retrieved 4 May 2011.

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Fish Production and Economic Growth in Nigeria: Co-integration and Causality Analysis

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Abstract

This paper explores the causal relationship between fish production and economic growth by employing the Johansen co-integration correlation and Granger causality approach. Annual time series data for the variables, fish production and, GDP per capita from 1970 to 2019 were used in the analysis. The tests on the long-run and short-run relationships between fish production and economic growth were conducted. Based on the findings of the co-integration approach this paper concludes that there is no long-run equilibrium relationship between fish production and GDP per capita. Granger causality test exhibits unidirectional causality running from fish production to GDP per capita and there is a positive relationship between fish production and GDP per capita.

Keywords: Fish production, Economic growth, Johansen co-integration, Granger causality.

Introduction

In Nigeria, like many coastal developing countries, fish is an important source of food for the population, which is currently estimated at 206.14 million people (World Bank 2021). Fish constitutes about 41% of the total animal protein intake by the average Nigerian hence there is great demand for fish in the country. Nigeria requires about 2.66 million metric tons of fish annually to satisfy the dietary requirement of its citizens (1206.14 Million) as the present estimated annual per caput fish consumption of 13.3 kg/capita/year in Nigeria is low compared with the world's average of 20.3 kg/capita/year (FAO 2018). The demand for fish in Nigeria is still not met, despite having a domestic production of about 0.8 million metric tons and about \$1.2 billion worth of fish being imported annually into the country. A deficit of 1.9 million metric tons still exists as the national demand for fish is about 2.7 million metric tons annually (Emefiele, 2019). The gap can only be bridged by sustainably increasing the growth rate of the sector. This will not only increase production and consumption but also lead to higher youth employment, increased household income, improved nutrition, and reduced child mortality.

Fish is crucial to nutrition in Africa (Chan et al, 2019). Ensuring adequate levels of animal-sourced food consumption is considered to be one key to combatting malnutrition (Headey et al., 2018). Africa experiences high levels of food insecurity and malnutrition (Akombi et al., 2017), and fish is among the most important animal-sourced foods across most of the continent (Desiere et al., 2018). This is also the scenario in Nigeria, where rates of malnutrition are high and fish is one of the main animal-sourced foods (Kuku-Shittu et al., 2016; Ogundari, 2017). The protein deficiency in the diet is equally associated with the inability of the fish farming industry to supply the required quantity of fish. The situation causes poor health, low efficiency, low productivity, and poor standard of living, and decline in the contribution of fishery industry to the Gross Domestic Product (GDP). The sector now contributes only 0.8% of the GDP (CBN 2019) and accounts for 0.2% of the total global fish production.

Fish supply is from four major sources viz., artisanal fisheries, industrial trawlers, aquaculture, and imported frozen fish (Akinrotimi, Abu & Aranyo, 2011). The Niger Delta contributes more than 50% of the entire Nigerian domestic fish supply, being blessed with an abundance of both fresh, brackish, and marine water bodies that are inhabited by a wide array of both finfish and non-fish fauna that supports artisanal fisheries (Akankali & Jamabo, 2011). However, the Nigerian fishing industry comprises three major sub-sectors namely the artisanal, industrial, and aquaculture of which awareness of the potential of aquaculture to contribute to domestic fish production has continued to increase (Adewuyi, Phillip, Ayinde & Akerele, 2010).

Despite the myriads of information on the integral role of the fishery sub-sector to the nation's economy, there exists a dearth of empirical information on the linkage between fishery production and economic growth in Nigeria and its perspective for sustainable economic development which ought to form the basis for policy formulation towards

enhancing the fishery sub-sector. Therefore, there is the need to fill the existing gap in the literature by providing empirical information on the nature of the causal relationship between fishery production and economic growth in Nigeria for the use of all stakeholders in the fishery sub-sector. Given the foregoing, this study was carried out to achieve the objective of establishing the causal relationship between fishery production and economic growth over the years in Nigeria and suggest relevant policy directions for sustainable economic development.

Fish farming is the least exploited fishery sub-sector with the vast brackish water fishing grounds almost unexploited (Ejiola & Yinka, 2012). Less than 1.0% of the freshwater grounds, and about 0.05% of the brackish water grounds are under aquaculture to produce a current average yield of 20,500 tonnes of fish per annum. This represents only 3.12% of the estimated fish culture potential of 656,815 tonnes per annum. Although the contribution of fisheries to the GDP is small (3-4%), it occupies a very significant position in the primary sector providing employment for over five hundred thousand people and contributing to over 40% of the animal protein intake of the people particularly the resource-poor (Sanni, Olowosegun, Sule, Muhammed, Yem, & Onimisi 2009). With an estimated 10 million Nigerians actively engaged in the upstream and downstream areas of fisheries operations in Nigeria, the contribution of the fisheries sub-sector to the nation's economy is significant, ranging from employment creation to the provision of raw materials for the animal feed industry (Osagie, 2012). Nigeria's vast inland water bodies and coastline measure over 800 km and support nearly 1.5 million people engaged in fish-based livelihoods (FAO 2007; World Fish 2017b). Nigeria produces around 1 million metric tons of fish per year: over 750,000 mt from capture fisheries and roughly 310,000 mt from aquaculture (WorldFish 2017). However, the role of aquaculture in Nigeria is growing, as the sector is becoming increasingly economically and politically incentivized. As of 2012, over 13,000 people were employed in aquaculture, though only 2% were women (FAO 2017).

Methodology

The present study is based on secondary data. The data for fishery production and GDP per capita in US dollars at the constant prices were obtained from World Development Indicators and the Federal Department of Fisheries for the period 1970-2020. Further, all of the series are transformed into a log form. Log transformation can reduce the problem of heteroscedasticity because it compresses the scale in which the variables are measured, thereby reducing a tenfold difference between two values to a two-fold difference (Gujarati 1995). The following time series are analyzed in this study:

1. LNFP = Log of Fish Production
2. LNGDPPC = Log of Gross Domestic Product Per Capita

Model Specification

To examine the relationship between fishery production and economic growth in Nigeria, the pairwise granger causality test was modelled as:

$$LFP_t = \beta_0 + \sum_{i=1}^n \beta_{1LFPt-i} + \sum_{j=1}^n \alpha_j LEG_t - j + \mu_{1t} \quad (1)$$

$$LEG_t = \phi_0 + \sum_{i=1}^n \phi_{1LEGt-i} + \sum_{j=1}^n \theta_j LFP_t - j + \mu_{2t}$$

(2)

Where:

LFP_t = Fishery production given by the index of fishery production

LEG_t = Economic growth given by real gross domestic product (N' million)

L = Natural logarithm.

Unit Root Test

Before testing for Johansen co-integration and Granger causality, the econometric methodology needs to examine the stationarity for each time series. The present study uses Augmented Dickey-Fuller (ADF) unit root tests to examine the stationarity of the data series. The Augmented Dickey-Fuller test consists of running a regression of the first difference of the series against the series lagged once, lagged difference terms, and optionally, a constant and a time trend. The additional lagged terms are included to ensure that the errors are uncorrelated. This can be expressed as follows:

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \alpha_2 Y_{t-1} + \sum_{j=1}^p \alpha_j \Delta Y_{t-j} + \epsilon_{tst} \quad (1)$$

Where ϵ_{tst} is a pure white noise error term and $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$,

$\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$ etc. The ADF test adjusts the DF test to take care of possible serial correlation in the error terms of adding the lagged difference terms of the regressant (Gujarati and Sangeetha, 2010).

Table 1: Unit Root Test Results

LFP	Test Stat	1% Critical	5% Critical	10% Critical	P-value	Remark
At Level	-0.663261	-3.574446	-2.923780	-2.599925	0.9901	1(0)
At 1 st Diff.	-10.30592	-3.574446	-2.923780	-2.599925	0.0000	1(1)
LNGDPPC						
At Level	-1.329883	-3.574446	-2.923780	-2.599925	0.6084	1(0)
At 1 st Diff.	-5.601802	-3.574446	-2.923780	-2.599925	0.0000	1(1)

The unit root test using Augmented Dickey-Fuller test at level shows that data is not stationary, but with the first difference result indicated that that all variables were stationary at 1% significance level.

Co-integration Test

Co-integration means that despite being individually non-stationary, a linear combination of two or more time series can be stationary. Co-integration of two or more time-series suggests that there is a long-run or equilibrium relationship between them (Gujarati & Sangeetha, 2010). The Johansen approach to co-integration test is based on two test statistics, viz: the trace test statistic, and the maximum eigenvalue test statistic.

Johansen Co-integration Test Statistics

Table2a: Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.172959	9.770408	15.49471	0.2988
At most 1	0.013556	0.655159	3.841466	0.4183

Trace test indicates no co-integration at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

Table 2b: Unrestricted Co-integration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.172959	9.115249	14.26460	0.2767
At most 1	0.013556	0.655159	3.841466	0.4183

Max-eigenvalue test indicates no co-integration at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

The results show that Trace Statistic value is below 5% critical value, therefore, it does not reject null hypothesis of "no co-integration". Similarly, Max-Eigen Statistic value is also lower than 5% critical value, which does not reject null hypothesis of no co-integration. The results thus suggest that there is no long-run stable relationship between GDPPC and fish production.

Results and Discussion

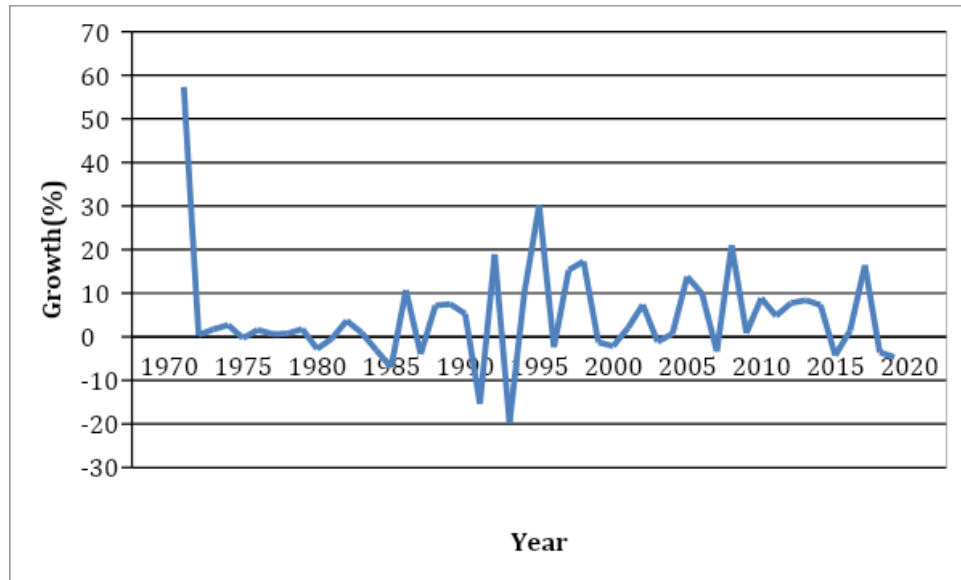


Figure 1: Trend Analysis of Growth of Fish Production in Nigeria 1970-2019

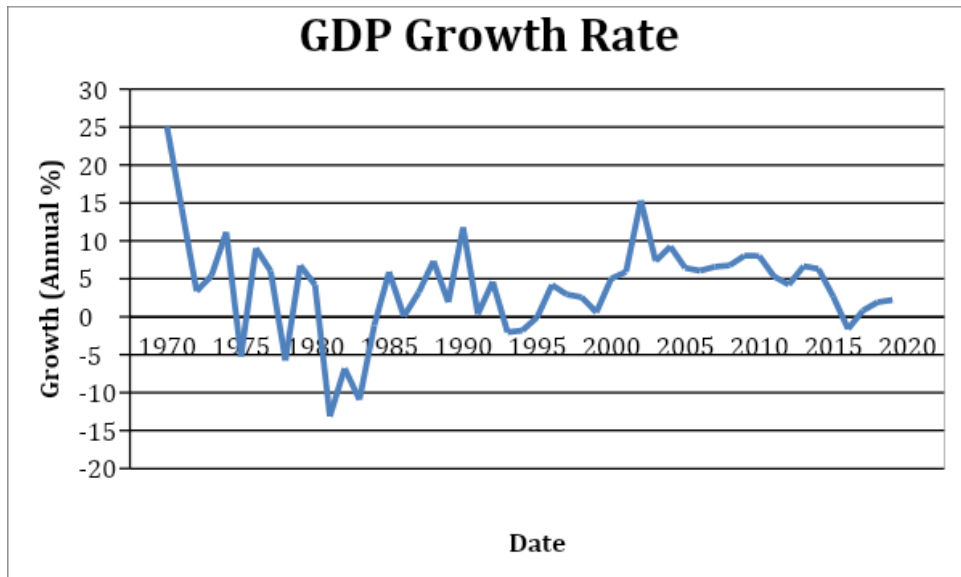


Figure 2: Trend Analysis of Economic Growth in Nigeria 1970-2019

The Granger Causality test

Causality is a kind of statistical feedback concept which is widely used in the building of forecasting models. Historically, Granger (1969) and Sim (1972) were the ones who formalized the application of causality in economics. Granger causality test is a technique for determining whether one-time series is significant in forecasting another (Granger, 1969). The standard Granger causality test (Granger, 1988) seeks to determine whether past values of a variable helps to predict changes in another variable. The definition states that in the conditional distribution, lagged values of Y_t add no information to the explanation of movements of X_t beyond that provided by lagged values of X_t itself (Green, 2003). The null hypotheses of the Granger-Causality test are:

$H_0: X \neq Y$ (X does not granger cause Y)

$H_1: X \neq Y$ (X does Granger-cause Y)

Result for Pairwise Granger Causality Test

Table 3: Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
LGDPPC does not Granger Cause LFP	49	0.18142	0.6721
LFP does not Granger Cause LGDPPC		3.20758	0.0799

Results of Pair-wise Granger causality test are presented in table 3. The results imply that Fish production granger cause GDP per capita while GDP per capita does not granger cause fish production. Hence, results show that causality is unidirectional (causality runs from fish production to GDP per capita).

Conclusion

This paper examined the relationship between fish production and GDPPC in Nigeria using time series data stemming from 1970 to 2019. Various econometric methodologies have been applied to investigate the short and causality relationship between fish production and economic growth.

The cointegration test does not confirm the existence of long run equilibrium relationship between fish production and GDP per capita. The Granger Causality test gives evidence that there exists unidirectional causality running from fish production to GDP per capita. Thus the results of Granger Causality test reflect the so-called ‘Dutch Disease’ where resources from the fisheries sub-sector were channeled to the industrial sectors. The researchers also established that there is a positive relationship between fish production and economic growth. Based on the findings of the study, it is recommended that government should adopt programs that would enhance increased productivity in the fisheries sub-sector of agriculture.

References

- Adewuyi S. A., Philip B. B., Ayinde I. A. and Akerele D. (2010). Analysis of Profitability of Fish Farming in Ogun State, Nigeria. *Journal Human Ecology* 31(3):179-184.
- Akankali, J.A. & Jamabo, N.A.(2011). A Review of Some Factors Militating Against Sustainable Artisanal Fisheries Development in Niger Delta, Nigeria. *Asian Journal of Agricultural Sciences*, 3(5): 369-377.
- Akinrotimi, O.A., Abu, O.M.G. & Aranyo, A.A.(2011). Environmental Friendly Aquaculture Key to Sustainable Fish Farming Development in Nigeria. *Continental Journal Fisheries & Aquatic Science*, 5 (2): 17 – 31.
- Akombi, B. J., Agho, K. E., Merom, D., Renzaho, A. M. and Hall, J. J. (2017). ‘Child Malnutrition in Sub-Saharan Africa: A Meta-analysis of Demographic and Health Surveys (2006–2016)’, *PLoS One*, 12(5),. e0177338.
- Central Bank of Nigeria, (2019). Annual Report for the Year Ended 31st December 2019
- Chan, C. Y., Tran, N., Pethiyagoda, S., Crissman, C. C., Sulser, T. B. and Phillips, M. J. (2019). ‘Prospects and Challenges of Fish for Food Security in Africa’, *Global Food Security*, 20, 17–25.
- Desiere, S., Hung, Y., Verbeke, W. and D’Haese, M. (2018). ‘Assessing Current and Future Meat and Fish Consumption in Sub-Sahara Africa: Learnings from FAO Food Balance Sheets and LSMS Household Survey Data’, *Global Food Security*, Vol. 16, pp. 116–126.
- Ejiola, M.T, & Yinka, O.F.(2012). Comparative Cost Structure and Yield Performance Analysis of Upland and Mangrove Fish Farms in Southwest, Nigeria. *International Journal of Agricultural Management & Development*, 2(3): 187-198.
- Food and Agriculture Organization. (2007). *Fishery profile: Country Report: The Federal Republic of Nigeria*. Rome: FAO. [ftp://ftp.fao.org/FI/DOCUMENT/fcp/en/FI_CP_NG.pdf](http://ftp.fao.org/FI/DOCUMENT/fcp/en/FI_CP_NG.pdf)
- FAO Food and Agriculture Organization.(2017). The State of World Fisheries and Aquaculture: Meeting the Sustainable Development Goals. Rome: FAO. <http://ftp.fao.org/docrep/fao/011/i0250e/i0250e.pdf>
- Godwin Emefiele (2019). Nigeria Needs no Fish Importations, *Vanguard*. [https:// www. Vanguardngr.com](https://www.Vanguardngr.com)
- Granger, C. W. J. (1969), “Investigating Causal Relations by Econometric Models and Cross-Spectral Methods,” *Econometrica*, 37, 424–438
- Granger, C. W. J. (1988), “Some Recent Developments in a Concept of Causality,” *Journal of Econometrics*, 39, 199–211.
- Greene,W.H. (2003), *Econometric Analysis*. Pearson Education, 5th Edition, 382.

- Gujarati, D.N. (1995). Basic Econometrics. (3rd ed.), New York, Tata McGraw-Hill
- Gujrati. N Damoder & Sangeetha (2010). Basic Econometrics. (4th ed.). New York, Tata McGraw Hill.
- Headey,D. Hirvonen,K and Hoddinott,J.(2018). Animal Sourced Foods and Child Stunting. *American Journal of Agricultural Economics*, 100(5)
- Kuku-Shittu, O., Onabanjo, O., Fadare, O. and Oyeyemi, M. (2016). Child Malnutrition in Nigeria: Evidence from Kwara State, Working Paper, *International Food Policy Research Institute*, Vol. 33.
- Ogundari, K. (2017). Categorizing Households into Different Food Security States in Nigeria: The Socioeconomic and Demographic Determinants. *Agricultural and Food Economics* 5(1)
- Osagie, C.(2012). Aquaculture as Path to Thriving Agriculture. Accessed online 5th October 2012 from <http://www.thisdaylive.com/articles/aquaculture-as-path-to-thriving-agriculture/124614>
- Sanni A. O., Olowosegun, T., Sule, A. M., Muhammed, A., Yem, I.Y. & Onimisi, H. U.(2009) Capacity Building and Training Requirement For Effective Fisheries And Aquaculture Extension In Nigeria - *A Review Nature & Science*, 7(4): 66 – 71.
- Sims, C. A. (1972), “Money, Income and Causality,” *American Economic Review*, 62, 540–542.
- World Bank (2021). World Bank Data Nigeria. Accessed on <http://data.worldbank.org/country/nigeria>
- WorldFish (2017a). CGIAR Research Program on Fish-Food Systems (FISH), Penang, Malaysia.
- WorldFish (2017b).WorldFish in Nigeria: Factsheet. Penang, Malaysia: WorldFish. *Factsheet*: 2017-17.

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Business Continuity and Sustainable Aquaculture Fish Production in Lagos State: A Review

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Abstract

Aquaculture has become very popular and acceptable as the safest and best process towards achieving self-sufficiency in fish production. The sustainability of the sector remains threatened by poor management skills, high cost of feeds, poor marketing strategies among others. Business continuity in aquaculture can be guaranteed when the fish farmer is protected against all forms of vulnerability and Lagos state, with its high potential for aquaculture and fish trade is the focus of this study. The authors adopted the review method in assessing the performance of aquaculture based on the analysis of data collected from the numerous fish farmers in Lagos State. From the study, while the sector has the potential to provide gainful employment and thus, income, it was found that some farms were being shut down due to high investment and operational costs. Also, it established that aquaculture fish farming could flourish and continue to sustain investors' economic pursuit.

Key Words: Business continuity, Aquaculture, Sustainability, Employment, Economic pursuit.

Introduction

Aquaculture activity in Nigeria commenced 50 years ago (Olagunju *et al.*, 2007) however, the report of FAO (2012) indicated that aquaculture production in Nigeria is about 200,535 metric tons (mt) contributing about 24% of domestic fish production. This value is a large increment considering its status as of 2006 when aquaculture production was about 40,000 mt contributing only 6% of domestic fish production (Adeogun *et al.*, 2007). Nigeria currently produces about 1,123,000 mt of fish against the national demand of about 3.32 million mt annually (Nigeria Fishery Statistics, 2016), which has kept increasing due to the increasing population and perceived health benefits of fish. Therefore to solve the high demand for fish, aquaculture production remains the best option to bridge the gap between fish demand and domestic production. In Nigeria, the aquaculture industry faces problems such as poor management skills, high cost of feed, inadequate supply of good quality seed, lack of capital, faulty data collection, lack of marketing of products and environmental impact consideration (Adewumi and Olaleye, 2011; Odebiyi and Olaoye, 2012). Also, the quality of fingerlings, labour input and, quality of feed are significant variables affecting fish farming (Muhammad-Lawal and Omotesho, 2010).

According to the World Fish Center (2010), challenges of aquaculture production include low production and poor sustainability, limited access to markets as well as inadequate supply of high-quality seeds. The limited availability and high costs of key aquaculture inputs (particularly feeds and fertilizers for ponds and feeds for pens and cages) have been adjudged as major causes of low productivity, especially for poor farmers. Also, standardized and stable strain nomenclature and certification of aquaculture seed, are not yet in place in Nigeria. Brown *et al.* (2017) divulged that there has been insufficient investment in the development of hatcheries and nurseries that are well-located to serve major and potential grow-out areas, while FAO (2015) said that resourcing of raw materials for feed products is one of the main issues affecting the sustainable production of farmed catfish.

Often, the aquaculture industry in Nigeria is usually referred to as "catfish farming" because it is native species and the hope of Nigeria's fish supply largely depends on its culture (Ozigboet *al*, 2014). The favoured catfish species in Nigeria aquaculture include: *Clarias gariepinus*, *Heterobranchus bidorsalis*, *Chrisichthys nigrodigitatus*, and *Clarias* with *Heterobranchus* hybrid (*Hetero clarias*) (Okonji and Afegbua, 2004). As revealed by Kudi *et al.* (2008), fish production in Nigeria is about 0.8 million mt against the national increasing demand of about 3 million metric tons. Thus, about 2.2 million metric tons need to be provided from elsewhere. Africa produced around 1.74 million mt of aquaculture produce – less than 2% of global production. This is mostly produced in Egypt (1.1 million mt) with other major producers being Nigeria (313,000 mt) and Uganda (111,000 mt) (FAO, 2016).

Nigeria is currently the second-fish producer of catfish products in Africa (FAO, 2017) and aquaculture is currently contributing about 0.48% to the overall agricultural GDP of 20.24% in Nigeria (Nigeria Fishery Statistics, 2016). In a report, Anetekhai (2017) divulged that the production output of *Clarias gariepinus* in Nigeria is over 253,898 mt per year. Although aquaculture production in Nigeria has experienced rapid growth in recent years, the industry is still constrained by inadequate feed supply (Udo and Umanah, 2017). Further, uncoordinated marketing and the presence of middlemen make fish sales unprofitable (Adelakun *et al.*, 2012). Seven major catfish value chain actors were identified by Gbigbi and Achoja (2019) and Oluwasola and Ige (2015). In Nigeria, aquaculture has the potential for meeting the increasing demand for protein; however, the sustainable development of the industry remains a question to be addressed (Adeogun *et al.*, 2012).

Materials and Methods

The study by Michael and Bula (2014) on assessment of marketing strategies of commercial fish farming applied a descriptive research design. This study targeted 667 fish farmers from the eight constituencies of Kitui County but only 200 fish farmers eventually responded. They were distributed in the eight constituencies of Kitui County which was selected for the study.

Adeogun *et al.* (2012) used a multi-stage sampling technique to obtain data from 700 fish farmers in all the twenty Local Government Areas (LGAs) in Lagos State during the 2008/2009 farming season. Information was collected using a structured questionnaire. They used the enterprise budgets analysis method (Jolly and Clonts, 1993) to measure the economic contribution of fish culture, to sum up the household income of the farmers.

Brown *et al.* (2017) worked on approaches for enhancing sustainable fish production among Farmers in Bayelsa State, Nigeria. They adopted survey research while the population of the study was 401 made up of 377 registered fish farmers and 24 (twenty-four) extension agents in the eight Local Government Areas of Bayelsa State but a total of 220 respondents were eventually interviewed. The instrument for data collection was a questionnaire, titled: Farmer's Sustainable Fish Production Enhancement Approaches Questionnaire (FSFPEAQ), which was made up of two parts. Part one was on personal data, made up of only three items, while part two was the content, made up of three sections: A, B, and C. Each FSFPEAQ item was anchored on a 4-point rating scale of Strongly Agreed (SA), Agreed (A), Disagreed (D), Strongly Agreed (SD) with corresponding nominal values of 4, 3, 2, and 1, respectively. The data collected were analyzed using descriptive and inferential statistics.

Fitriah *et al.* (2019) which examined the effects of marketing mix on small fish farming business performance used a total of 150 questionnaires distributed to the respondents. The independent variable for the study was the marketing mix.

Results and Discussion

The summary of results obtained by Michael and Bula (2014) are presented in Tables 1.1- 1.3.

Table 1.1: Count Attributes Associated with Effective Marketing

	Strongly Agree	Agree	Indifferent	Disagree	Strongly Disagree	Total
Branding is minimal	120	55	15	10	0	200
Branding is poor	91	102	1	6	0	200
Inadequate branding	77	93	23	4	0	200

Source: Michael and Bula (2014)

Table 1.2: Sales Promotion Methods Required for Commercial Fish Product

Methods	Frequency	Percentage
Personal selling	148	74
Advertising	41	20.5
Shows and exhibition	8	4.0
Mobile telephony connectivity	3	1.5
Total	200	100

Source: Michael and Bula (2014)

Table 1.3: Computed Values for the Four Regressors

Regressors	Coefficient	p value
Constant(β_0)	5.138	0.001
product branding(β_1)	0.912	0.003
sales promotion(β_2)	0.435	0.002
market positioning(β_3)	0.498	0.003
core competencies(β_4)	0.652	0.001
unknown parameters(e)	0.023	0.000

Source: Michael and Bula (2014)

The p-value of 0.003 for product branding which is less than 0.005, implies that product branding has a significant influence on the effective marketing of fish products in Kitui County. Similarly, the p-value of 0.002 for sale promotion being less than 0.005 denoted that sales promotion has a significant influence on the effective marketing of fish products in Kitui County. In the same trend, a p value of 0.003 (marketing positioning), p value of 0.001 (core competencies) being lower than 0.005 implies that those variables have a significant influence on the effective marketing of fish products in Kitui County.

Michael and Bula (2014) divulged that branding was found to greatly affect the marketing of the fish products. It was also found that the government and the community were the major financiers of the branding. However, farmers indicated that there was no specific criterion that the committee of product branding to facilitate the marketing of fish products could follow. Most farmers (74.0% of the farmers) use personal selling as the method of selling their fish products. The other sales promotions included advertising (20.5%), shows and exhibition (4.0%), and mobile telephony connectivity (1.5%). However, inadequate sales promotions do affect the effective marketing of fish products. The study by Michael and Bula (2014) also established that inadequate training was a major factor affecting competence in the marketing of commercial fish farming while positioning of the market affected marketing greatly as revealed by 86.5% of the farmers.

The summary of production costs and profit margin of profitable enterprise techniques examined in Lagos State is as shown in Table 2.

Table 2: Summary of Production Costs and Profit Margin of Profitable Enterprise Technique in Lagos State

Enterprise technique	Production cost(N/Kg)				Profit margin(N/Kg)			
	Mean	Max.	Min.	Total(N)	Mean	Max.	Min.	Total(N)
SCFLP	91.61	338.52	18.85	32.00	277.14	406.53	11.48	32.00
SPFLP	127.35	337.75	42.50	30.00	253.65	430.18	12.25	30.00
SPJLT	154.58	339.51	39.49	32.00	207.92	425.09	10.49	32.00
SEFLP	171.17	397.96	35.31	35.00	210.83	351.94	2.04	35.00
SEJLP	141.94	353.46	33.89	31.00	208.38	406.22	10.41	31.00
FTSCJLT	49.36	157.32	19.42	30.00	314.64	380.58	224.14	30.0
FTSCJIT	111.47	333.61	20.61	30.00	235.20	351.70	16.39	30.00
FTSPJLP	138.11	395.28	20.28	39.00	209.71	341.05	4.12	39.00
FTSPJLT	133.09	371.15	17.22	44.00	235.55	401.22	3.85	44.00
WRSDCJLT	54.91	182.47	13.40	49.00	296.11	384.34	167.53	49.00
WRSDCJIT	105.65	276.35	13.00	33.00	265.26	372.07	93.65	33.00
WRSDPJLT	103.13	342.25	13.28	33.00	254.45	470.90	7.75	33.00
WRSNCFLT	138.92	376.92	21.28	33.00	205.47	355.35	5.31	33.00
WRSNCFIT	118.41	390.79	21.39	34.00	232.33	367.03	0.64	34.00

WRSNPJIT	90.73	364.02	24.11	32.00	264.90	400.89	46.83	32.00

Source: Adeogun *et al.* (2012)

Adeogun *et al.* (2012) got results of the profitability ratio that varied from 2.6 in technique SEFLP to 10.8 in FTSPJLT while the mean overall profitability was 4.7. The F-value (6.08) showed a significant difference in the profitability ratio of different fish farming enterprises. This indicates that fish farming in Lagos State achieved, on the average, some levels of profitability that should guarantee its economic sustainability. Further analysis by Adeogun *et al.* (2012) revealed that FTSPJLT has the highest mean profitability and was highly significant from other techniques except for WRSDCJLT. This equally explains that both techniques (FTSPJLT and WRSDCJLT) are characterized by a high level of profitability and the difference in profitability between the two techniques may be a result of random error. They concluded that a one-naira N1.00 invested in FTSPJLT would generate N10.60k. Fitriah *et al.* (2019) used the path coefficient to test the hypotheses proposed for their research model as shown in Table 3. The assessment of the path coefficient showed that only two (H2 and H4) out of four hypotheses were supported and significant at $p < 0.5$ with beta values (β) of 0.189 for H2 and -0.352 for H4. H1 is not supported, even though the t-value shows that it is significant. Pricing strategies had the highest impact on the positive business performance for the small-scale fish farming businesses (H2). This impact was significant and positive and has the highest path coefficient in the model. On the other hand, business performance is not influenced by place (H3) ($\beta = -0.114$, $t = 1.023$, not significant) and product (H1) ($\beta = 0.106$, $t = 0.954$, not significant). As a result, H1 and H3 are not supported.

Table 3: Path Coefficient and Hypothesis Testing

Hypothesis	Relationship	Path Coefficient (β)	t statistics (O/STDEV)	P Values	Decision
H1	Product Business Performance ->	0.106	0.954	0.341	Not supported
H2	Price Business Performance ->	0.189	2.015*	0.045	Supported
H3	Place Business Performance ->	-0.114	1.023	0.308	Not supported
H4	Promotion Business Performance ->	-0.352	4.031**	0.000	Supported

Source: Fitriah *et al.* (2019)

The items that were used by Fitriah *et al.* (2019) are productivity, growth, profitability, sales, market share, quality, number of employees, and overall performance adopted from previous studies such as Murat *et al.* (2011) and Rubio and Aragon (2009). The results of their study indicated that price and promotion were supported and significant. Also, the results of the price indicated that the higher pricing strategy adopted led to a higher result of business performance. Francis and Collins-Dodd (2004) have established that the relationship between business performance and promotion was negative but significant. The result of adopting a promotion strategy was negative towards the performance and this might be because of several possibilities. Thus, if the managers use poor judgment in modifying the positioning and promotional mix, the execution might be poor and the timing of promotion adoption could be wrong. However, in the study by Fitriah *et al.* (2019), place and product strategies were not significant, which means they are not important to the business performance. They were not important in the sample case because they had the same product characteristics (i.e fresh fish only) and they sold their product at the same market.

Table 4.1: t-test Analysis of the Mean Ratings of the Responses of Fish Farmers and Extension Agents on Breeds of Fish Reared by Farmers in Bayelsa State.

Status	N	Mean	Standard deviation	Degree of freedom	t-cal	p value	Remark
Fish farmers	196	3.63	0.56	218	-1.45	0.09	Not significant
Extension Agents	24	3.83	0.38				

Source: Brown *et al.* (2017)

Table 4.2: Mean Ratings and Standard Deviation of Respondents on Methods used by Fish Farmers for Sustainable Fish Production in Bayelsa State (n=220: n₁=196 Fish Farmers; n₂=24 Extension Agents).

Item statement	Mean	Standard Deviation	Remark
Earthen pond	3.58	0.65	Agreed
Concrete pond	3.52	0.42	Agreed
Reinforced plastic pond	2.36	0.65	Disagreed
Ordinary plastic pond	2.31	0.65	Disagreed
Cages in natural waters	3.55	0.25	Agreed

Source: Brown *et al.* (2017)

The results from Brown *et al.* (2017) showed that there was no statistically significant difference between the mean ratings of fish farmers and extension agents on the breeds of fish (Catfish, Tilapia, Heterobranchus, and Mudfish reared by farmers in Bayelsa State. The findings of Brown *et al.* (2017) also showed that three methods (earthen pond, concrete pond, and cages in natural waters) were used extensively by fish farmers for sustainable fish production in Bayelsa state. However, there was no statistically significant difference between the mean ratings of fish farmers and extension agents on methods (such as good planning prior to the establishment of a fish pond, visits to successful fish farms, accessing government interventions with funds or infrastructure, access to corporate organization, formation of fish farmers associations, making reference to farm records for improvement and access to loans or credit facilities) used by fish farmers for sustainable fish production in Bayelsa State.

Recommendations

To ensure sustainable Aquaculture Fish Production in Lagos State, the following are recommended

- There should be coordination of the sector to ensure sustainability and this must be integrated into aquaculture development programs or projects from the very beginning to take the best advantage of the industry's potential.
- There should be a forum to define different stakeholder groups and their interests in the major geographical zones in the country so that research can be adapted to suit their capacities and needs. In line with this, it becomes imperative for the appropriate community-based sustainable, ecological integrated aquaculture systems to evolve in each geographical zone.
- All international funds meant to support farmers, such as ECOWAS Funds for Assisted Fish Production Project and Fisheries and Aquaculture Growth Enhancement Support Scheme (GES),(FAO, 2016) should be evenly distributed among farmers in Nigeria.
- Standardization and certification of fish farms, hatcheries, fish processing centers, and feed mills must be done nationwide to ensure the equality of fish products.
- Establishing greater opportunities for a strong market, increased productivity, and continuity of expanded profit is fundamental to curtailing the current dramatic levels of fish imports from across the world.
- Reform is needed in many segments of the aquaculture industry to promote more responsible development. This, in turn, requires an integrated view of aquaculture, one that considers not only environmental and economic sustainability, but also, social responsibility.
- Stakeholders should provide enabling environment for experts to package sustainable approaches into training programmes for farmers through Agricultural workshops and seminars.
- There is a necessity to conduct a value chain assessment to identify the economic growth and enterprise development opportunities.
- Aquaculture sector should engage more in important public-private sector partnerships to promote improved management and sustainability.

- j) Government should establish programs to ensure equitable and broad participation of stakeholder participation in management planning, decision-making, implementation and enforcement. Programs should both focus on how achievements will be sustainable beyond the end of the activity's lifetime and seek to identify continued financing for ongoing activities.

Conclusion

Aquaculture businesses have been greatly diversified with various findings indicating profitability of the enterprises and scientific advances have stimulated the growth of aquaculture in Lagos State. However, the increase in abandonment of farms in Lagos state calls for an urgent investigation to find out the panacea towards sustainability of aquaculture business in Lagos State and Nigeria at large.

References

- Adelakun, K. M., Oguniwin, D. I., Ajagbe, S. O. and Ijagbeni, A. B. (2012). Sustainable Aquaculture Practise: A Profitable Venture in Nigeria. In: Handzic, M., Subasi, A. and Goksu, A. (eds), Green Information Technologies and Strategies. *Proceedings of the 3rd International Symposium on Sustainable Development*, ISSD 2012, May 31 - June 01, 2012, Sarajevo. Vol. 3 Part 1, 265 – 272.
- Adeogun, O. A., Alimi, T. and Adeyemo, R. (2012). Status, Cost and Profitability of Aquaculture Enterprises in Nigeria: Implications for Food Security. *International Journal of Agricultural Sciences*, 2 (1): 59- 66.
- Adeogun, O.A, Ogunbadejo, H.K, Ayinla, O.A and Oresgun, A. (2007). Urban Aquaculture: Producer Perceptions and Practices in Lagos State Nigeria. *Middle-East Journal of Science Research* 2(1): 21 - 27.
- Adewumi, A. A. and Olaleye, V. F. (2011) Catfish Culture in Nigeria: Progress, Prospects, and Problems. *African Journal of Agricultural Research*, 6: 1281-1285.
- Anetekhai, M. A. (2017). Catfish Aquaculture Industry Assessment in Nigeria. A Technical Report by AU-IBAR, 2017.
- Brown, T. J., Agbulu, O.N. and Amonjenu, A. (2017). Approaches for Enhancing Sustainable Fish Production among Farmers in Bayelsa State, Nigeria. *Journal of Fisheries and Livestock Production*, 5(3):1-6.
- FAO (2017).Fishery and Aquaculture Statistics.Global Aquaculture Production 1950-2015 (Fishstat). In: FAO Fisheries and Aquaculture Department. Rome.
- Food and Agriculture Organization (FAO). (2016). *FAO Fisheries and Aquaculture Fishery and Aquaculture Country Profiles*. The Federal Republic of Nigeria. Retrieved from <http://www.fao.org/fishery/facp/NGA/en>.
- FAO (2015). Report of the Eighth Session of the Sub-Committee on Aquaculture. Brasilia, Brazil, 5–9 October.FAO Fisheries and Aquaculture Report.No.1131. Rome, FAO. <http://www.fao.org/3/ai5191t.pdf>.
- FAO (2012).The State of the World Fisheries. Food and Agriculture Organization, Rome, Italy 230pp.
- Fitriah, A.W., Rosdi, S.N., Rosli, M. M., Mustapha,N., Aziz, Z.A., Ibrahim, W. M. Y., Mohd, S.N.R., Aniesha, N.Z. and Yaacob, A.A. (2019). The Effects of Marketing Mix on Small Fish Farming Business Performance, *RevistaPublicando*, 6 (19): 1-16.
- Francis, J., and Collins-Dodd, C. (2004). Impact of Export Promotion Programs on Firm Competencies, Strategies, and Performance: The Case of Canadian High-Technology SMEs. *International Marketing Review*, 21(4/5), 474-495.
- Gbigbi, T.M. and Achoja, F.O. (2019).Cooperative Financing and the Growth of Catfish Aquaculture Value Chain in Nigeria. *Croatian Journal of Fisheries*, 77, 263-270.
- Kudi, T.M., Bako, F.P. and Atala, T.K. (2008). Economics of Fish Production in Kaduna State, Nigeria, *ARPN Journal of Agricultural and Biological Science*, 3 (5 and 6): 17-21.
- Michael K. M. and Bula, H. O. (2014).Marketing Strategies of Commercial Fish Farming under Economic Stimulus Programme (ESP) in Kenya: An Empirical Study of Kitui County. *International Journal of Humanities and Social Science*, 4,8(1):111-121.
- Muhammad-Lawal, A. and Omotesho, O.A. (2010). Economic Analysis of Fish Farming in North Central Nigeria: A Case Study of Kwara and Kogi States. *Journal of Agricultural Research and Development*, 9(1): 21 – 36.
- Jolly, C.M. and Clonts, H.A. (1993). *Economics of aquaculture*. New York. Food Products Press.
- Nigeria Fishery Statistics Report (2016).
- Odebiyi, O.C. and Olaoye, O.J. (2012).Small and Medium Scale Aquaculture Enterprises (SME's) Development in Ogun State, Nigeria: The Role of Microfinance Banks. *Libyan Agriculture Research Center Journal International*, 3(1): 1 – 6.
- Olagunju F. I., Adesiyun I. O. and Ezekiel A. A. (2007). Economic Viability of Catfish Production in Oyo State, Nigeria. *Journal of Human Ecology*, 21(2). 121-124.

- Oluwasola, O and Ige, A. O. (2015). Factors Determining the Profitability of Catfish Production in Ibadan, Oyo State, Nigeria. *Sustainable Agriculture Research*. 4(4), 2015. ISSN 1927-050X E-ISSN 1927- 0518. Canadian Centre of Science and Education.
- Ozigbo, E., Anyadike, C., Adegbite, O. and Kolawole, P. (2014). Review of Aquaculture Production and Management in Nigeria. *American Journal of Experimental Agriculture*, 4(10): 1137-1151.
- Udo, I. U. and Umanah, S. I. (2017). Current Status of the Nigerian Aqua Feeds Industry: A Review. *International Journal of Innovative Studies in Aquatic Biology and Fisheries* (IJISABF) 3(1): 14-22.
- WorldFish Centre (2010). Barriers to Aquaculture Development as a Pathway to Poverty Alleviation and Food Security. Presentation by M. Beveridge, M. Phillips, P. Dugan and R. Brummett to the OECD Workshop, Paris, 12–16 April 2010.

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Economic of Aquaculture for sustainable Fish production and Employment Generation in Kano State, Nigeria

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Abstract

This study was carried out to examine the relationship between Aquaculture and economic growth with a view to drawing up relevant implication for sustainable economic development of Kano State, Nigeria. The research identified Burrow pits as an important aquaculture system for expanding fish food security, income generations and poverty reductions among fish farmers. In most parts of Northern Nigeria burrow – pits are seasonal in their water holding capacities and retain water for not more than 3 - 4 months. However, Sallarin burrow-pit in Tarauni, Kano, retains water for fish farming throughout the year. Structured questionnaire and personal interviews data were collated and analyzed using descriptive statistics involving the use of measures central tendency, frequency, percentages, gross margin, table, narrative and pictorial formats and results discussed. Major challenges identified by this study include lack of good quality seed for recruitment, water quality maintenance and burrow – pit ownership. The paper concludes on an optimistic note for a better development of aquaculture in the country with positive professional policy measures for production and marketing.

Key words: sustainable fish production, employment generation, Kano State, Nigeria

Introduction

Aquaculture has grown strongly in most regions of the world where the potential exists, except in Africa. In the entire African region only Egypt has achieved the scales of change observed in Asian countries (FAO 2006). Fish culture began in Nigeria over five decades ago and endowed with substantial marine and inland fisheries resources, with land area of 923,768km, however, it has not been able to bridge the gap between domestic consumption and domestic output (Alhaji, 2020). The current annual demand for fish in Nigeria is 3.25million metric tons while the domestic production stands at 1.027million metric tons, leaving a huge deficit of 2.223million metric tons (FDF 2015). The difference between Nigeria fish demand and consumption has to be bridge through importation of both frozen and smoked fishes, making Nigeria to be the largest importer of fish in Africa. The over relying heavily on fish importation both frozen and smoked, thus a net total valued of fish importation cause the country of about USD\$1,126,428,414.41and able to exports valued at about USD\$56,067,915.00(FDF, 2015).The variance between production and consumption implies high market potentials in the fishing industry (Alhaji, 2020). However, the limited capacity of the Nigeria fisheries sector to meet the domestic demand has raised a number of pertinent questions both in policy circle and among researchers.

Aquaculture in Kano is important in prioritizing agricultural growth and effectiveness of overall economic growth which will leads to poverty reduction, market opportunities and price effective. The development of aquaculture in Kano State, Nigeria was primarily driven by socio-economic objectives such as supplementary income generation, improvement of nutrition in rural/urban locations and employment creation. Despite the huge potentials Nigeria fishing industry's performance (artisanal, industrial capture and aquaculture) is weak and requires urgent interventions (Alhaji, 2020). In Complementing and improving the fishing sector, the development of aquaculture needs to ensure long term sustainability of fish and other aquatic supplies.

Kano State aquaculture industry is characterized by the culture of African catfish, tilapia, carp and *Heterotis niloticus*. The African catfish species (*Clarias* spp. and *Heterobranchius* spp.) are the most cultured species due to their hardiness, wide acceptability and high market value. These species are usually reared to acceptable market size within a culture period of 4–13 months, depending on the adopted production system (Adewumi 2015). The success story of the aquaculture industry in Nigeria is primarily hinged on catfish farming (Adewumi and Olaleye 2011) and accounts for over 80% of aquaculture production in Nigeria. For the sector to play a vital role in ensuring future fish availability for food security and nutrition in Kano State, the sector has to develop and grow in an economically viable and environmentally sustainable means. (Francis 2019), opined that fisheries is highly relevant in meeting

Sustainable Development Goals (SDGs) with the most obvious contribution in terms of food security and livelihoods, rich food for poor people. Hence, increasing the efficiency of resource use and productivity at the farm level is indispensable to sustainable aquaculture. Improved water management, better feeding strategies, genetic improvement of stocks, and improved health management are some way to enhance productive efficiency of fish farming at the farm level.

Methodology

Primary data were collected using structured questionnaire administered to 96 randomly selected from individual that had different backgrounds from Four Local Government of Kano State, Nigeria. Focus group discussion, direct feedback mechanism was adopted during the study for further confirmation of some issues raised. Physical observations were made to Farms and Burrow pits.

The data were collated and analyzed using descriptive statistics involving the use of measures central tendency such as, frequency, percentages, gross margin, table, narrative and pictorial formats and results discussed.

Hence GM is calculated as $TR - N = TVC$

Where GM is gross margin, TR is total revenue, N is net income and TVC is total variable cost.

Results and Discussion

Socio-Economic Characteristics of Fish Farmers

The socio-economic characteristics of the respondents in the study area are shown in Table 1. Majority of the respondents 58% were within the economically active age group 21--40 years. The retired and other senior member of the society form the remaining 42%, as reported by Achilike and Matanmi (2014) that most of fish farmers were in their active years. The aquaculture industry in Kano is dominated by married persons with 78%, while widow occupied second position with 11% and single and separated 6% each. The result show an impressive educational status of fish farmers in the state with only 20% without formal education, 32% had tertiary education, 24% had primary education while 18% had secondary and 7% had vocational knowledge. Table 1 also reveals that, 92% are full time fish farmers while 8% respondents are temporary fish farmers. 49% of the respondent indicated ownership of the farm, 24% are squatting (Burrow - pits), 22% are family own property and 5% of the respondent rent the facility to culture fish. Fish farming in an open space (Burrow pits and Dams) is dominated by male with 80% and 20% female probably due to culture and religion. (Agwu, 2007) reported that in Africa fish farming are predominantly male activities.

Table 1: Socio – Economic Characteristics of Respondents

Variable	Frequency	Percentage
Age		
21-30	31	31.76
31-40	25	26.82
41-50	29	28.84
51-60	11	12.56
>61	0	0
Total	96	100
Marital Status		
Married	79	77.84
Single	4	5.81
Widow	9	10.54
Separated	4	5.81
Total	96	100
Educational Status		
No formal education	19	19.54
Primary	23	23.68

Secondary	17	17.82
Tertiary	31	31.76
Vocational	6	6.76
Total	96	100
Status 1		
Full time fish farmer	91	92.16
Temporary	5	7.8
Leisure	0	0
Total	96	100
Resource Issues		
Own land	49	48.84
Rent land	3	4.88
Family land	21	22.18
Government	0	0
Squatting	23	24.10
Total	96	100
Gender		
Male	80	79.8
Female	16	19.8
Total	96	100

Sources: Field survey 2021

Figure 1 (plate A, B, C, D, E, F) is the Sallari Burrow pits in Kumbotso, Kano State, it is larger than standard football field. Different fish species are cultured at the same time. Harvesting is control by Chairman of the burrow – pit, fish sold within or taking to other markets. Plate ‘E’ shows different species of fish harvested and processing for smoking. Calabash (gora), hooks, nets and traps are the fishing gear used in this Burrow pit.



Figure 1: Burrow pit at Sallari, Tarauni Local Government, Kano State, Nigeria.

Source: Field survey 2021.

Conclusion

This study analyzed the influence of socio-economic factors of fish farmers in Kano. The critical success driving aquaculture development and production output in Kano State were high per capita consumption of fish, awareness

on health benefits of fish, profitability of the fishing industry, huge population, optimal environment, infrastructure, technology, commercialization, provision of an enabling environment and skill development. Key challenges plaguing the pace of aquaculture development in the state are land ownership (fish farm), lack of access to credit facilities, adequate supply of required quantity and quality of seed, high cost of fish feeds, marketing and Government policies has exacerbated further aquaculture products.

References

- Achilike, N.M. and M. A. Matanmi (2014). Women in fish farming. A case study of Eriwe Fish Farm Village Ijebu-Ode, Ogun State, South-West Nigeria. Proceedings of the 29th Annual Conference of the Fisheries Society of Nigeria held at Makurdi. Pp 218 -222.
- Adewumi A. 2015. Aquaculture in Nigeria: sustainability issues and challenges. Direct Res J Agri Food Sci. 3:12.
- Adewumi A, Olaleye V. 2011. Catfish culture in Nigeria: progress, prospects and problems. Afr J Agri Res. 6(6):1281–1285.
- Agwa, A. E. and E. O. Afioroho (2007). Influence of personal and Institution Factors on Adoption of improved pond management practices among fish farmers in Isoko Local Government Area, Delta State. In: Nigeria Journal Animal Production, 34 (1):121 -131.
- Alhaji T.A, Jim-Saiki L.O., Ogunbadejo H.K and Mohammed R. (2020). The Effects of Imported Fishes on Nigeria Fishing Industry. Niger 2020, Fisheries Society of Nigeria (FISON). 35th Annual Conference, 15th – 19th November, 2020. Raw Material, Abuja.
- FAO. 2016. The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all. Rome: FAO. p. 200. [Google Scholar]
- Federal Department of Fisheries (FDF) (2015) Fisheries Statistics of Nigeria. Federal Department of Fisheries Area 11, Garki, Abuja, FCT, Nigeria. Fifth Edition.
- Francis D. Sikoki (2019). National Coordinator, International Atomic Energy Agency (IAEA), Technical Cooperation Projects, University of Port Harcourt, Rivers State, Nigeria. A keynote address delivered at the 34th Annual Conference of the Fisheries Society of Nigerian, FISON, held from the 28th October to 1st November, 2019 at the International Conference Centre, Abakaliki, Ebonyi State, Nigeria.
- Nigeria Fisheries Statistics (2016). Fishery Committee for the West Central Gulf of Guinea. Summary Report.
- Otubusin, S. O. (2011). Executive summary of the Nigeria water sector road map. Federal Govt. of Nigeria. 2011. 49p.

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Fish Transportation Challenges and Marketing Strategies in Kainji Lake Basin, Niger State

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Abstract

This study was designed to have an overview of the prevailing domestic fish marketing scenario in the study areas. A two stage sampling method were used to select fish marketers. Thus, a total of 110 structured questionnaires were administered, of which 90 was finally used for this research, fish marketers constitute the sample size for the study. Data analyses were carried out using descriptive statistics and percentage. Result of the study revealed that 75% of fish marketers in the study area were within the age range of 31 to 50 years, road transportation (100%) was the major means of transportation used by respondents. The major constraints associated with transportation in the study area were, bad roads (100%), high cost of fuel (75%), and delay in payment (62.5%). However, majority of the respondents (62%), transport their fish to loading point (Total Filling Station, New Bussa) , while 25% of the respondents sends their produce straight to Onitsha, Major strategies employed by respondents are creation of sale point (2.10 ± 0.82) and maintaining market contact via the use of mobile phone (2.0 ± 0.68). It is recommended amongst others, that government should provide basic amenities such as conducive roads and lastly, financial institution should encourage the fish marketers with credit facilities to boost their fish marketing.

Keywords: Marketing, Transportation, Fish.

Introduction

Fish is an important source of protein in developing countries. However, it is highly perishable especially in the hot climate where unsanitary environment and poor handling practices worsen the situation (Ikeme, 2006). Marketing of fresh fish passes through several market participants and exchange points before they reach the final consumers. It is a chain of different systems involved in the marketing from production to consumer with intra-linkages and inter-linkages. At various stages in the marketing chain, fish has to be packed and un-packed, loaded and un-loaded to meet consumer demand. Each handling cost will not amount so much but the sum total of all loading can be significant, depending on the length of chain (Ali *et al.*, 2008). Subsequently, a greater difference in price paid between urban consumers at the end of the chain and river bank price at the beginning of the chain can lead to a greater or wider market margin between the producer and the final consumer. However, when the market margin is high, it may be used to argue that producers or consumers are being exploited. Nonetheless, high margin cannot be completely justified (Ali *et al.*, 2008). Fish supply and marketing suffer so many obstacles ranging from shortage of supply, price fluctuation and spoilage in transit. Despite these, the people involved in the marketing of the fresh fish appear to increase because of rise in the population which may lead to increase in demand. Olukosi and Isitor (1990) opined that marketing margin is an important indicator of market performance. Usually, the middlemen performing the role of marketing are being accused of earning higher profits in the marketing system (Bryceson, 1993). Analysis of fresh fish marketing is important considering the fact that fish and fish products contributed 6% to the gross domestic product (GDP) of Nigeria in 2006 (Areola, 2007). The broad objective of the study is to make available, empirical information on transportation pattern or strategies indulged by fish marketers in kainji lake basin, Nigeria. The study was specifically designed to identify transportation channels, destination of the transported fish and the challenges in fish transportation in the study area.

Methodology

The study will be carried out in Kainji Lake Basin (KLB), with a maximum length of 134km and a maximum width of 24.1km, it has a depth of 60 (Max) and 11m (mean). It is located between longitude 4° 21' and 4° 45' East and latitude 9° 5' and 10° 55' North. It cuts across Niger and Kebbi States with the greater part located in Niger State. The lake is the 2nd largest manmade lake in Nigeria, with a surface area of 1270km² (Ayeni and Mdaihi, 1996). The study was carried out in the following 9 fishing communities: Malale, wara, Monai, Dugamashaya, Nassarawa, cover dam, New Bussa, Musawa, kokoli and Shagunu. A total of 100 structured questionnaires were purposively administered among the respondents in which 90 were used for the analysis. The target respondents were randomly

selected from fish farmers who have been harvesting their farms and selling. The data collected were subjected to descriptive statistics.

Result and discussion

The age distribution of respondents as shown in Table 1 below, indicates that most (75.0%) of the respondents were within the age groups of 31-50 years, while 25.0% comprised of respondents whose age range was above 50 years. This suggests that most of the respondents in the study area are in the active years and therefore actively involved in fish transportation activities. The table also shows that the sex distribution of the respondents was such that 87.5% of them were male while 12.5% of them were female. This implies that transportation in fish farming is a male dominated enterprise in the study area. Majority of the respondents had one form of education or the other, secondary education having the highest per cent (62.5%), while primary and tertiary each have 25% and 12.5% respectively, implying that literacy level of fresh fish marketers in the area was fairly high. This is in line with the findings of Dongongari and Baba (2010) who observed that high literacy level could have positive correlation with agricultural technologies. The major occupations in the study area include, fish farming and transportation which are 37.5% each and artisan 25%. Fish farming distance is also a factor worth considering in terms of volume of production in fish farming and agriculture at large. This is due to the fact that a lot of factors must be considered before and after production of agricultural products such as market, demand of the product, competition, mode and type of transportation, access to the market and so on (Ogunmefun, *et al* 2017). Therefore, Figure 1, showed that all (100%) of the farmers use road as their means of transportation, the transport route is a highly valid point and the length of distance covered might influence the size of the fish, depending on how bad the road is. And vehicle used are mostly hired (62.5%). Figure 2 above, shows the various destinations in which the fish marketers transport their fish to for sales, majority of the respondents (62%), transport their fish to loading point (Total Filling Station) where it will finally be sent to Onitsha, 25% of the respondents sends their produce straight to Onitsha, while 13% takes theirs to processing unit for sales within and personal use. Figure 3 shows respondents cost of transportation per carton to their destination, 48%, pays #70 per carton (small size), while 40% and 12% of the respondents pays #150 (medium size) and #1000 (large size) respectively to Onitsha. Fish passes through several intermediaries from the landing centre or fish pond to the consumer. The intermediaries are involved in providing services of head loading, processing, preservation, packing and transporting and these activities result in cost addition at every stage of marketing (Bishnoi, 2005). The key intermediaries in fish marketing are: auctioneer, wholesaler, retailer and the vendor. Several other intermediaries like local fish collectors and fishermen cooperatives also exist in several markets. Table 3 above, presents the constraints faced by fish marketers. The problem of bad roads ranks highest as virtually all the respondents agreed to the fact. The problem of bad road would in turn affect the cost of transportation and as well delay the conveyance from one place to another. This is in line with the findings of (Nwabeze *et al*, 2011), who stated that, exorbitant cost of marketing, occasioned by high transportation of the product could drastically reduce, if the fishing communities are opened up with net-work of good roads and other basic amenities such as electricity and water. Other constraints as identified by the respondents include; high cost of fuel (75.0%) and delay in payment (67.5%). Hike in fuel price would automatically have a multiplier effect on transportation and consequently on fish marketing. Conversely, delayed payment could hamper or hinder further transactions among fish marketers. Table 4 indicates the solutions proffered by the respondents in the study area, asserting that, government intervention 100% is paramount, including prompt payment 62.5%. When payment is promptly made, fish transporters will be able to have good turnover that will bring about increase in production, thereby leading to increase in income and better standard of living.

Conclusion

The study shows that fish transportation cannot be over emphasized due to the fact that it will help improve the standard of living of respondents in the study area, by creating more awareness on how best to transport their fish. The study established that fish marketers in the study area were mostly dominated by literate young males, while road transportation was the major means of transportation as virtually all respondents attested to the fact. Problem of bad road, high cost of fuel and delay in payment were major constraints to fish marketing in the study area.

Table 1: Socio-economic characteristic of respondents

Variables Categories		Frequency	Percentage
Age	31-40yrs	34	37.5
	41-50yrs	34	37.5
	51-60yrs	22	25.0
Sex	Male	78	87.5
	Female	12	12.5
Marital Status	Married	79	87.5
	Single	11	12.5
Educational Background	Primary	23	25.0
	Secondary	56	62.5
	Tertiary	11	12.5
Main Occupation	Transporter	23	25.0
	Fish Farmer	34	37.5
	Artisan	33	37.

Source: Field Survey 2018

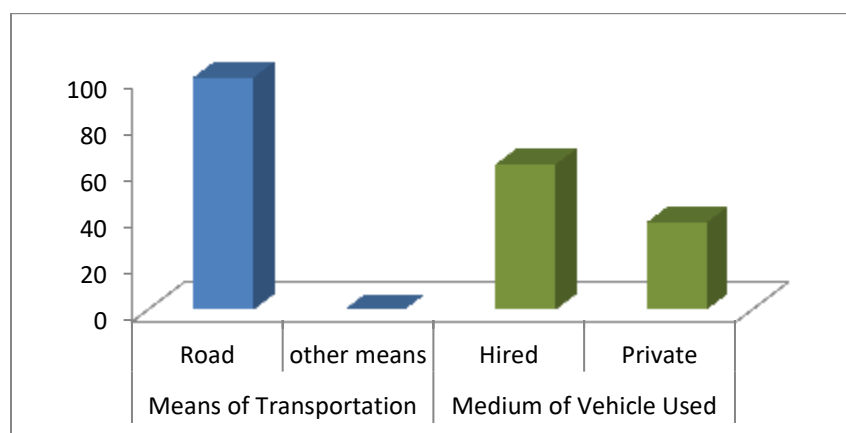


Figure 1: Transportation Channels and vehicle used

Source: Field Survey 2018

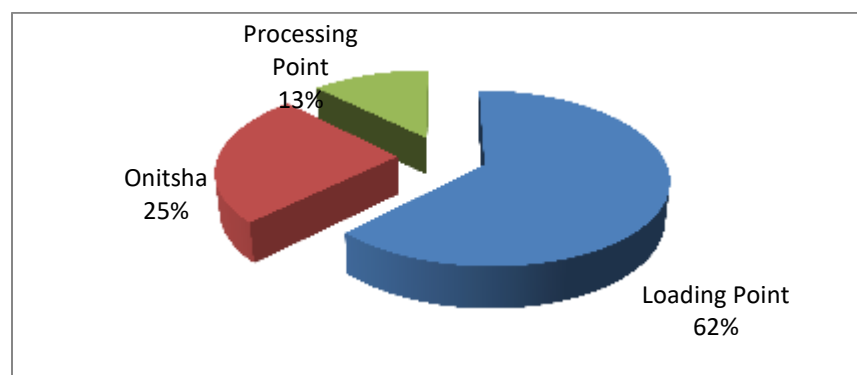
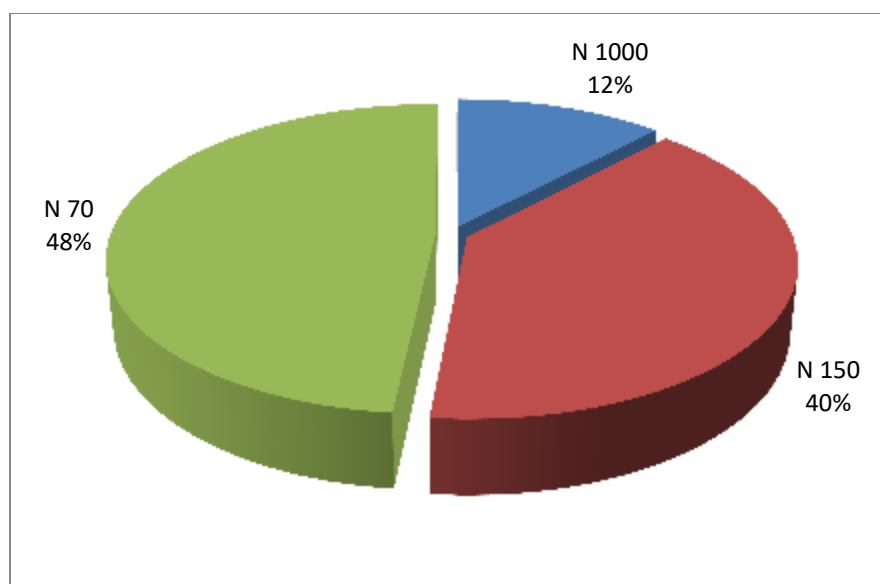


Figure 2: Area of Transport (Destination)

Source: Field Survey 2018

**Figure 3: Cost of Transportation**

Source: Field Survey 2018

Table 3: Constraints faced by respondents

Bad road	90	100.0
Delay in payment		
Yes	56	62.5
No	34	37.5
Total	90	100.0
High cost of fuel		
YES	67	75.0
NO	23	25.0
Total	90	100.0

Source: Field Survey 2018

Table 4: Solution proffered by the respondent

Government intervention	90	100%
Prompt payment		
YES	56	62.5
NO	34	37.5
Total	90	100%

Source: Field Survey 2018

Reference

- Alam, J.M., R. Yasmin, A. Rahman, N. Nahar, N.I. Pinky and M. Hasan, 2010. A study on fish marketing system in Swarighat, Dhaka, Bangladesh. *Nature and Science*, 8(12): 96-103.
- Ali, E.A., H.I.M. Gaya and T.N. Jampada, 2008. Economic analysis of fresh fish marketing Inmaidugurigambaru market and kachallariaudam landing site of North-Eastern, Nigeria. *Journal of Agriculture and Social Sciences*, 2(4): 23-36.
- Areola, F.O., 2007. Fish marketing and export potentials of fish and fisheries products of Nigeria. Paper Presentation at the Workshop on Sustainable Fisheries Livelihood and Food Security in Nigeria. Fisheries Society of Nigeria, April 16th 19th 2007, pp: 45-52.
- Bishnoi, Tanuj Kumar (2005) *Marketing of Marine Fisheries*, Sonali Publication, New Delhi, pp. 74-76.

- Bryceson, D.F., 1993. Liberalizing tangamia food trade; public and private faces of urban marketing policy 1939 – 1988. London: UNRISD James Carry.
- Dongondaji, S.D. and K.M. Baba, 2010. Income distribution in large scale irrigation projects: A case study of dry season rice farmers at the Bakolori irrigation project, Zamfara state, Nigeria. Proceedings of the 24th Annual National Conference of the Farm Management of Nigeria held at the Adamawa State University, Mubi 11th- 14th October, 2010. pp: 49-58.
- Esobhawan, A.O., Ikehloa, E.E and Nwabeze, G.O (2011). Cost and returns in artisanal fishery production in Edo State, Nigeria. *Nigerian Journal of fisheries science and technology volume 2(2). 2011.*
- Ikeme, A.I., 2006. Cooperative research programmes on fish technology in Africa. Nsukka: Food and Technology Department, University of Nigeria. pp: 154.
- Ogunmefun, S. O. and Achike, A. I. Agricultural Science Research Journal Vol. 7(10): 304 – 317, October 2017 Available online at <http://resjournals.com/journals/agricultural-science-research-journal.html> ISSN: 2026 – 6073 ©2017 International Research Journals.
- Olukosi, J.O. and S.U. Isitor, 1990. Introduction to agricultural marketing and prices, principles and application. Abuja, Nigeria: Living Books Series GU Publications. pp: 169.

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Investment and Employment Opportunities in the Aquaculture Value Chain in Nigeria**Jamabo, N. A., Nkeeh, D. K. and Ogbonnia, J. M.**

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Abstract

Aquaculture plays an important role in the development of many national economies and a key role in the socio-economic resilience of rural areas. Nigeria's freshwater aquaculture technology is developing, still undergoing research. Value chain in aquaculture includes all the key activities carried out to move aquaculture products from farm to final consumer. This paper relied on literature from previous studies to outline the investment and employment opportunities in the aquaculture value chain in Nigeria. Investment opportunities in aquaculture include; seed/fingerlings production, grow-out farms, broodstock production, fish processing/ value addition, storage and distribution, and agro journalism. Employment opportunities in aquaculture include; farm manager/ supervisor, digital marketing, and professional consultancy. In the face of the increasing rate of unemployment in Nigeria, adequate investment in the development of the aquaculture subsector of agriculture will go a long way to create employment opportunities for Nigerians.

Keywords: Aquaculture, Investment, Value chain, Agro journalism,

Introduction

Nigeria is Africa's most populous country and its largest economy (Nukpezah and Steensma, 2020). Out of 181 countries with published unemployment rates within 2019 and 2020, Nigeria currently ranks as the 41st country with the highest unemployment rate in comparison with other countries across the world (National Bureau of Statistics, 2021). According to the labor force reports for the first quarter of 2021 published by the National Bureau of statistics under-employment rate fell to 22.8% (figure 1) while unemployment rates rose to 33.3% (figure 2) from 27.1% in Q2 2020 and 23.1% in Q3 2018.

Aquaculture plays an important role in the development of many national economies and a key role in the socio-economic resilience of rural areas, potentially offering valuable and skill-based employment opportunities, and in some cases stabilizing the economic base of otherwise fragile communities (Edwards, 1999; Haylor and Bland, 2001; Muir, 1999). It provides livelihood options in rural areas of the developing world, as well as income and employment in both remote regional and more developed economies (Adeoye *et al.*, 2012). This paper aims to explain the aquaculture value chain and to highlight opportunities that exist to promote sustainable progress in the Aquaculture sector.

Although aquaculture has grown strongly in most regions of the world where the potential exists; it has not done so in Sub-Saharan Africa. Despite various efforts since the 1950s, returns on government and international aquaculture investments appeared to be insignificant (FAO, 2004) with less than 5% of the suitable land area being used. The demand for fish in Nigeria is still not met, despite having a domestic production estimated at 800,000 metric tonnes. The demand stands at about 2.1 million metric tonnes per year. There is a shortfall of about 1.3 million metric tonnes. To solve this problem Nigeria has turned to fish importation while several other policies are being put in place by successive administrations to improve on local production (Akinsorotan *et al.*, 2019).

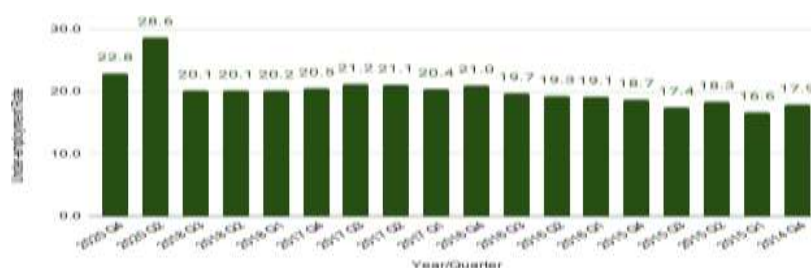


Figure 1: Under-employment Rate - Q4 2020 in Nigeria (National Bureau of statistics, NBS, 2021)

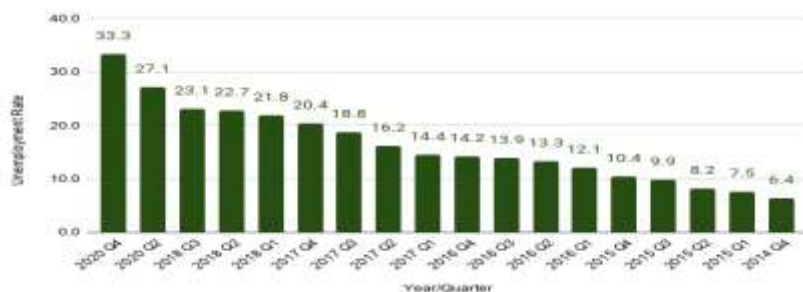


Figure 2: Unemployment Rate - Q4 2020 in Nigeria (NBS, 2021)

Previous studies by Niger Delta Environmental Survey, NDDDES (1997), reveal that opportunities exist in nearly all aspects of the fishing industry. Concerning aquaculture, some of the areas for possible investment include production of fishing equipment, the establishment of modern fish farms, shrimp fishing, establishment of an ice-melting plant; fish processing for export, fish fingerling production, table size fish production, broodstock production; fish seed production, ornamental fish farming, production system design and construction, processing and preservation. Others are capacity building in project management, fabrication of fish handling equipment, packaging and branding, agro journalism and professional consultancy (Ekelemu, 2014). Some cultivable fish species cultured in Nigeria, which are capable of thriving well in the freshwater environment according to Akinsorotan *et al.* (2019), include: *C. gariepinus*, *Clarias lazera*, *Heterobranchus bidorsalis*, *Heteroclaris*, *Tilapia sp.*, *Tilapia mariae*; *Oreochromis niloticus*, *Oreochromis mossambicus*, *Sarotherodon galilaeus*; *Sarotherodon melanotheron*, *Tilapia zilli*, *Tilapia guineensis*, *Hereterotis niloticus*, *Chrysichthys nigrodigitatus* and *Cyprinus carpio* e.t.c. However, there have been three major freshwater fish genera farmed in Nigeria, namely; *Clarias*, *Tilapia* and *Heterotis* (Amosu, 1997).

Current State of Aquaculture in Nigeria and the Aquaculture Value Chain

Apart from the earthen ponds, tank cultivation is characterized by high yield, with its efficiency dependent on aeration, water quality and flow rate, (Emmanuel *et al.*, 2014). Tanks are usually made from treated wood, concrete or PVC plastic and fiberglass, with capacities ranging from a few hundred liters to several thousand cubic meters (Akinsorotan *et al.*, 2019). Even though this cultivation technique is a capital intensive venture, the input is usually relatively quickly recovered if the system is well managed. Nigeria freshwater aquaculture technology is developing, still undergoing research and has gained steady recognition, due to the increasing demand for cheap sources of protein and livelihood that has seen the need for sustainable production (Amosu *et al.*, 2012).

Aquaculture Value Chain

The value chain in aquaculture includes all the key activities that are carried out to move fish/ aquaculture products from farm to final consumer. Value chain can be divided into four categories, namely; pre upstream, upstream, mid-stream and downstream.

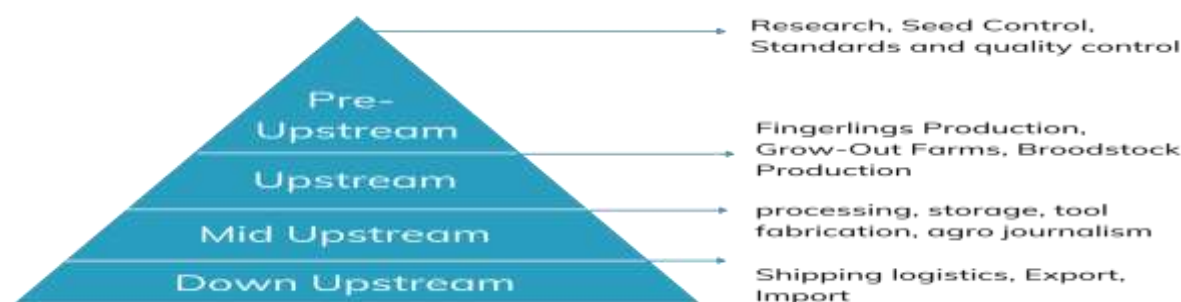


Figure 3: The Aquaculture Value Chain Triangle
(Source: Ogbnonnia, 2021)

Investment and Employment Opportunities in Aquaculture Value Chain in Nigeria

Investment Opportunities

Seed / Fingerlings Production

Production of quality fingerlings is the bedrock of success in the aquaculture production sector. As important as this is, there are only a few qualified experts that fully understand the biological, physiological and environmental needs and traits of the fish currently in culture (African Catfish). Little and Hulata (2000), outlined the strategies for tilapia seed production.

Grow-Out Farms

This is the most popularly practiced, which entails the buying of fingerlings and growing them to table size for commercial purposes. Examples of facilities used; concrete tanks, plastic tanks, earthen ponds, fiberglass and tarpaulin ponds. Ayyappan and Jena (2008) reported the potentials of grow-out production of carps in India.

Broodstock Production

A broodstock is a male or female mature fish that is used to produce young fish through a process popularly known as breeding. This is the production and culture of fish to use them as parents to other fish. A good broodstock properly cultured will produce quality eggs and milt which when breed will result in the hatching of quality fry. Broodstock producers can actively serve the fingerlings producers. Where proper facilities and workforce capacity exists, the producer of fingerlings can as well be a broodstock producer. Okumus (2002), reported the relevance of rainbow trout broodstock production and management in Turkey.

Fish Processing/ Value Addition

Processing refers to mechanical or chemical operations performed on fish to transform or preserve them (FAO 2021). Fish are processed in a variety of ways and in different working environments. Removing the entrails from fish (e.g. gutting or cleaning) is a simple processing technique designed to extend shelf life.

Storage and Distribution

Products of fish processing (dried, salted and dried, smoked) often undergo a period of storage before being sold, distributed and consumed. Such storage typically takes place at the processing location and/or at a different holding facility close to the market. Individuals can invest into storage facilities to help the farmers lose less produce to post-harvest loss, and for cases of multi-dollar investment companies, a cold storage facility can be developed, this is capital intensive and expensive to maintain, given that round the clock electricity supply will be needed to achieve the goal of the storage and distribution investors. Importantly, product type, moisture content, design of storage facility, length of storage time, humidity, temperature, hygiene and sanitation practices can influence the likelihood of food loss and waste (FLW) during storage. Products can be stored for up to several months depending on these variables, particularly the type of product and its moisture content (FAO *et al.*, 2021).

Agro Journalism

This is a specialized field of communications, focused on reporting news and information about the food system from “farm to fork” or “gate to plate,” as some consumers phrase it (Alex, 2021).

Agricultural Journalism can be described as that part of social activity, which is primarily concerned with the gathering, packaging and reporting of agricultural-related news and views to the public promptly. An example of this is the popular Port Harcourt YouTube show - Food full TV, where sustainable aquaculture practices are discussed, whilst participants watch this show, it increases traffic and in return pays the producer/creator of such beneficial videos.

Employment Opportunities

Farm Manager/ Supervisor

Oyebola *et al.* (2020), in “employment and income effects of Nigeria’s Agricultural Transformation Agenda: Evidence from cattle value chain”, highlighted the roles of a farm manager/supervisor. All fish farms rely on the experience and technical know-how of a professional to run their establishment; this could be the owner of the establishment or a hired professional. Thus, seasoned graduates of fisheries who have acquired relevant experiences

can apply to manage big-time farms in and beyond the borders of Nigeria. Such individuals must seek to grow capacity in business management, project management and execution.

Digital Marketing

With increasing focus on technology, digital operations, economy, remote working and learning, the purchasing habits and buying pattern of people generally has tilted in favor of online purchases and home delivery post-covid-19. This concept has revolutionized what is largely referred to as E-commerce. Consumers of fish and fisheries products are not left behind on this trend, thus, it has widened the market spectrum and made it possible for farmers to connect with consumers of their products without the help of middlemen who largely eat up their profit. This sector is characterized by such mediums as Facebook, Instagram, Twitter and YouTube (Social Media Marketing), online markets on websites and mobile applications such as Jumia, Konga, etc. also referred to as E-commerce stores.

Professional Consultancy

Many existing fish farmers started their business without proper training and consultations, because of the myth that fish farming requires no training and is easy to maneuver. A large percentage of such individuals have constantly been disappointed, and have been struggling to break even. This is because aquaculture deals with life fish that possess physical, biological, chemical and environmental characteristics that must be mastered by the farmer to be able to manipulate the fish stock to grow and perform well, the risks are high. The importance of professional consultancy in aquaculture can't be overemphasized (Ekelemu, 2014).

Conclusion

In the face of the increasing rate of unemployment in Nigeria, adequate investment in the development of the aquaculture sector will go a long way to create employment opportunities for Nigerians.

References

- Adeoye, A., Yemi, A.-S., Omoniyi, T. and Dipeolu, A. O. (2012). *Challenges and Investment Opportunities for Large Scale Aquaculture Farmers in Nigeria*. Research Gate.
- Akinsorotan, A. M., Akinsorotan, O. A., Jimoh, J. O., Adene, I. C. and Akiwowo, U. A. (2019). Offshore aquaculture practice; a potential for meeting Nigeria fish demand – a review. *Journal of Physics: Conference Series*, 1299.
- Alex, A. (2021, June 1). Importance of agricultural journalism. Afribary.com. <https://afribary.com/works/importance-of-agricultural-journalism>
- Amosu, A. O. (1997). *Possible Aquaculture in Nigeria Ojo, Lagos* (Lagos State University, B.Sc. thesis).
- Amosu, A. O., Bashorun, O. W., Babalola, O. O., Olowu, R. A. and Togunde, K. A. (2012). Impact of Climate Change and Anthropogenic Activities on Renewable Coastal Resources and Biodiversity in Nigeria. *Journal of Ecology and the Natural Environment*, 4(1), 201-11.
- Ayyappan, S. and Jena, J. K. (2008). Grow-out production of carps in India. *Journal of Applied Aquaculture*. Volume 13 (3-4): 251-282.
- Edwards, P. (1999) Aquaculture and overtly: Past, present and future prospects of Impact. Fifth Fisheries Development Donor Consultation, Rome, Italy, 22-24 February 1999 . Rome. Italy.
- Ekelemu, J. K. (2014). *A Review of Aquaculture Production in Nigeria: Problems and Prospects*.
- Emmanuel, O., Chinenye, A., Oluwatobi, A., and Peter, K. (2014). Review of Aquaculture Production and Management in Nigeria. *American Journal of Experimental Agriculture*, 4(1), 51- 1137.
- FAO (2004). Aquaculture extension in sub-Saharan Africa. FAO Fisheries Circular. No. 1002. Rome, FAO. 55p.
- FAO, Ward, A., and Penarubia, O. (2021). *Food Loss and Waste in Fish Value Chains*. Food and Agriculture Organization of the United Nations. fao.org/flw-in-fish-value-chains/value-chain/processing-storage/en/
- Haylor, G. and Bland, S. (2001) Integrating aquaculture into rural development in coastal and inland areas. In: Subasinghe,

- R.P., Bueno, P., Phillips, M.J., Hough, C., McGladdery, C.E. and Arthur, J.R.e., (Eds.) Aquaculture in the third millennium technical. Proceedings of the conference on aquaculture in the third millennium, Bangkok, Thailand, 20-25 February 2000, pp. 73-81. Bangkok, Thailand and FAO, Rome, Italy: NACA and FAO.
- Little D.C., Hulata G. (2000) Strategies for tilapia seed production. In: Beveridge M.C.M., McAndrew B.J. (eds) Tilapias: Biology and Exploitation. *Fish and Fisheries Series*, 25:112-120
- Muir, J. (1999) Aquaculture and Poverty: Full Baskets or Empty Promises? Perspectives from DFID Aquaculture Research Programme. Paper presented at the Fifth Fisheries Development Donor Consultation, 22-24 February, FAO, Rome.
- National Bureau of Statistics (NBS). (2021, March). *Labor Force Statistics: Q4 2020* [Unemployment and underemployment Report].
- Nukpezah, J., & Steensma, J. (2020). *The Aquaculture Postharvest Value Chain in Nigeria*. Mississippi State University. Retrieved June 7, 2021, from <https://www.fishinnovationlab.msstate.edu/newsroom/2020/08/aquaculture-postharvest-value-chain-nigeria>
- NDES (1997). The Niger Delta Environmental Survey. Environmental and Socio-Economic Characteristics. Lagos, Nigeria: Environmental Resources Managers Limited.
- Okumus, I. (2002). Rainbow Trout Broodstock Management and Seed Production in Turkey: Present Practices, Constraints and the Future. *Turkish Journal of Fisheries and Aquatic Sciences* 2:4-56.
- [Oyebola, F.](#), [Osabuohien, E.S.](#) and [Obasaju, B.O.](#) (2020). "Employment and income effects of Nigeria's Agricultural Transformation Agenda: Evidence from cattle value chain", [*African Journal of Economic and Management Studies*](#), 11(2): 317-329.

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Agricultural Sector Evaluation and the Nigerian Economy: Employment Trends and Implication

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Abstract

This study evaluates employment in the agricultural sector and its productivity impacts in economic development to the sector. Secondary data sourced from World Bank data archive, federal bureau of statistics and federal department of fisheries 2019 were used to describe and analyse the impact of employment to agricultural development. Using descriptive analysis with plots/table representation and Pearson's correlation, the relationship between employment in agricultural sector and its productivity was determined. The study revealed that its employment ratio to the total workforce in Nigeria reduced from 48.39% in 2010 to 34.97%. Nigeria attained her highest rates of agricultural value-added per worker in 2017. This value stood at \$ 5852.15 while \$ 4083.25 recorded for 2010 was the lowest value added per worker for the study period. It was also revealed that the nation's highest GDP (NGDP) and Agricultural GDP (AGDP) were recorded in 2014. These values were 546.68 billion US\$ and 109.28 billion US\$ respectively. Pearson's correlation analysis showed that there is a strong positive correlation between the employment in agricultural sector and Agriculture value added (USD). With correlation coefficient of 0.799, it clearly signifies that increase in agriculture labour force consequently leads to rise in Agriculture value added (USD).

Key Words: Employment, GDP, Labour Force, Pearson's correlation

Introduction

The economy of Nigeria is a middle-income, mixed economy and emerging market, with expanding various sectors. According to the World Bank, middle-income countries (or MICs) are nations that have a per capita gross national income (GNI) between \$1,026 and \$12,475. Nigeria is ranked as the 27th largest economy in the world in terms of nominal GDP, and the 24th largest in terms of purchasing power parity (World Bank review, 2020). The country has the largest economy in Africa. Its re-emergent manufacturing sector became the largest on the continent in 2013, and it produces a large proportion of goods and services for the region of West Africa (manufacturing sector report, 2015). In addition, the debt-to-GDP ratio was 16.075% as at 2019.

Nigerian GDP at purchasing power parity (PPP) has grown from \$170 billion in 2000 to \$451 billion in 2012. Subsequently, the GDP per capita doubled from \$1400 per person in 2000 to an estimated \$2,800 per person in 2012. These values exclude contribution from informal sector. The country's population increased from 120 million in 2000 to about 206 million in 2010. Although oil revenues contributed 2/3 of state revenues, oil only contributes about 9% to the GDP. Although the petroleum sector is important, as government revenues still heavily rely on this sector, it remains a small part of the country's overall economy.

The largely subsistence agricultural sector has not kept up with the country's rapid population growth. Nigeria was once a large net exporter of food, but currently imports some of its food products. Mechanization has led to resurgence in the manufacturing and exporting of food products, and there was consequently a move towards food sufficiency. As countries develop, the share of the population working in agriculture is declining. While more than two-thirds of the population in poor countries works in agriculture, less than 5% of the population does in rich countries. It is predominantly the huge productivity increase that makes this reduction in labor possible. Hence, there is need to maximize productivity gains and make it possible to optimize the agricultural land and human resources needed to feed the rising population of Nigeria.

Materials and Method

The study used secondary data sourced from World Bank data archive, FAO-stat, federal bureau of statistics and federal department of statistics to describe and analyse results derived from the study using descriptive analysis with

plots/table representation. Pearson's correlation was used to determine the relationship between employment in agricultural sector and its productivity. Data sourced were total population, labour force, employment in agriculture, industry and service sectors in Nigeria from 2010 to 2020. Also considered were the Nation's GDP (current US\$), Agriculture GDP (current US\$) Agriculture (% of GDP), Agriculture, (constant 2010 US\$), GDP per person employed (constant 2017 PPP \$), GDP per capita (current US\$), GDP per capita (constant 2010 US\$) and Employment in agriculture in Nigeria from 2010 to 2020. These data were analysed using descriptive and inferential statistics and results obtained were presented in tables and plots.

Results and Discussion

Over the period reviewed as seen in table1 and fig.1, the agricultural sector witnessed an overall decline in employment. Its employment ratio in total workforce reduced from 48.39% in 2010 to 34.97% while the ratio of employment in the service sector rose from 48.39% in 2010 to 53.03% in 2019. However, employment in the industry sector remained relatively stable. Though, its employment ratio rose slightly from 10.25% in 2010 to 12.0% in 2019.

Further examining the agricultural productivity with regards to labour force in the agricultural sector, fig 2 shows that the agriculture value-added per worker which is a measure of labour productivity and also corresponds to the ratio between value added in agriculture (constant 2010 US\$) and number of people employed in agriculture, Nigeria attained her highest rates of agricultural value added per worker in 2017. This value stood at \$5852.15 while \$4083.25 was recorded as the lowest which was the value recorded for 2010.

Table1 Demography of Nigeria population size and labour force per sector from 2010 to 2020

Year	Population	Labour force	Labour/ population ratio (%)	Employment in services (% of total employment)	Employment in industry (% of total employment)	Employment in agriculture (% of total employment)
2010	158503203	53143752	33.5285	48.39	10.25	41.36
2011	162805080	54535983	33.49772	49.27	10.15	40.58
2012	167228803	53686203	32.10344	49.58	10.95	39.47
2013	171765819	52794910	30.73656	49.92	11.81	38.27
2014	176404931	53696560	30.43938	50.61	11.89	37.51
2015	181137454	54557234	30.11925	51.12	11.94	36.94
2016	185960244	55285972	29.73	51.42	12.03	36.55
2017	190873247	57856159	30.3113	51.9	12.05	36.05
2018	195874685	60517054	30.8958	52.46	12.02	35.53
2019	200963603	63226720	31.46178	53.03	12	34.97
2020	206139587	62242961	30.19457	N/A	N/A	N/A

Source: World Bank data

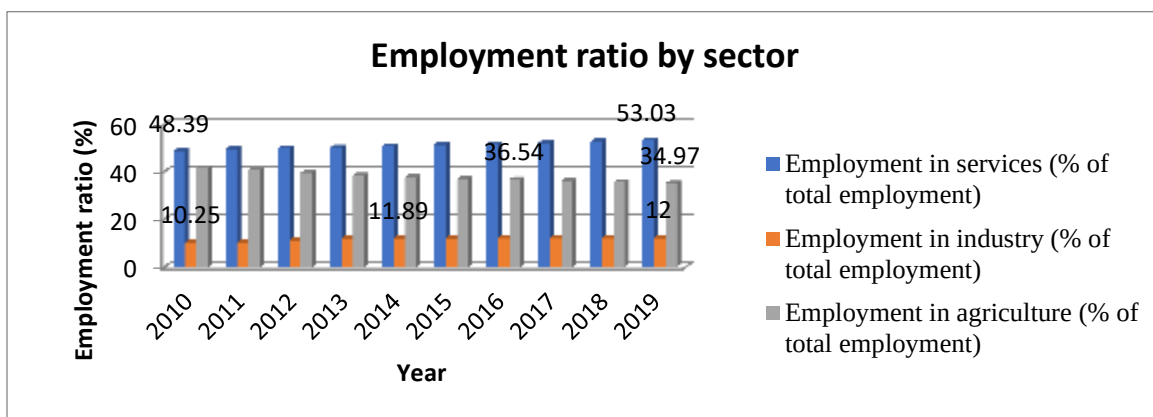


Fig 1: Employment ratio by sector (service, industry and agriculture) to total employment in Nigeria

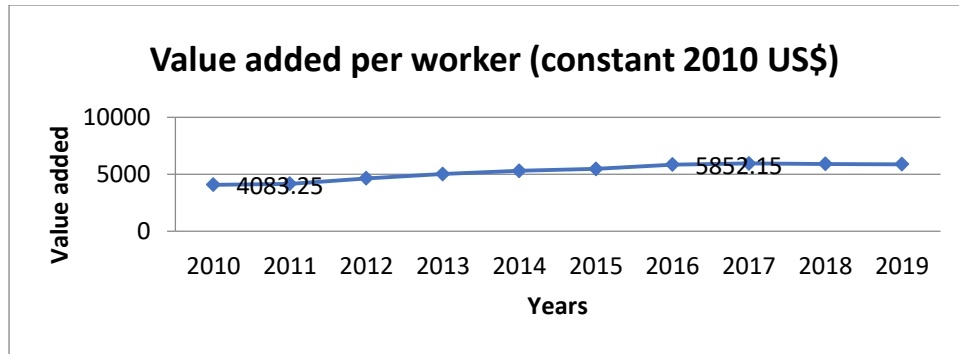


Fig2: Value added per worker (constant 2010 US\$) from 2010 to 2019

Table 2: Shows National Gross Domestic Product (NGDP), Agriculture Gross Domestic Product (AGDP) and Employment in agriculture in Nigeria from 2010 to 2020

Year	GDP (current US\$)	AGDP (current US\$)	Agriculture (% of GDP)	Agriculture, (constant 2010 US\$)	GDP per person employed (constant 2017 PPP \$)	GDP per capita (current US\$)	GDP per capita (constant 2010 US\$)	Employment in agriculture
2010	3.61457E+11	86365375731	23.8937	4083.259	15287.57	2280.437	2280.437	21980256
2011	4.04994E+11	90049155195	22.23471	4173.644	15687.62	2487.598	2338.026	22130703
2012	4.55502E+11	99572444770	21.85996	4649.624	16604.52	2723.822	2372.461	21189945
2013	5.08693E+11	1.05598E+11	20.75862	5017.73	18004.65	2961.549	2463.889	20204612
2014	5.46676E+11	1.09282E+11	19.99025	5295.786	18989.32	3098.986	2550.47	20141579
2015	4.86803E+11	1.00437E+11	20.63189	5474.466	19133.18	2687.48	2549.723	20153441
2016	4.0465E+11	84908154779	20.98311	5852.147	19124.62	2176.003	2443.441	20207022
2017	3.75746E+11	78330256171	20.84657	5950.564	18690.86	1968.565	2399.732	20857145
2018	3.9719E+11	84219371562	21.20377	5898.742	18225.09	2027.779	2383.42	21501709
2019	4.4812E+11	98166587270	21.9063	5877.594	17846.67	2229.859	2374.369	22110385
2020	4.32294E+11	1.0437E+11	24.14331		17898.07	2097.092	2273.219	N/A

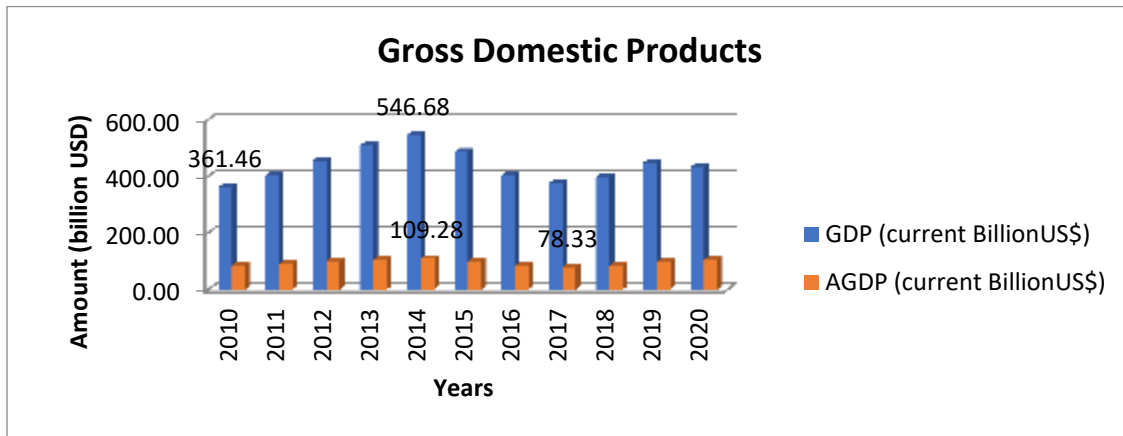


Figure 3: Nigeria gross domestic product (GDP) and agricultural gross domestic product (AGDP)

Fig 3 simply explains the importance of the agricultural sector in the Nigeria economy. This was reflected as both the national GDP and agricultural GDP showing fairly similar trend in distribution. For the period studied, Nigeria recorded its highest National GDP and agricultural GDP in 2014. These values stood at 546.68 billion US\$ and 109.28 billion US\$ respectively. However, the corresponding growth in value (amount) did not signify similar growth in proportion agriculture contributes to the national GDP; rather in contrast, the ratio contributed in 2014 was the least recorded between 2010 and 2020. In 2014, agriculture's contribution was 19.99% and the highest contribution recorded as 24.14% for 2020 of the national GDP came from agriculture that year.

Table Analysis: Pearson's Correlation Matrix of the National GDP, Agricultural GDP and Employment in Agriculture.

<i>GDP</i>	<i>Nation's GDP (current US\$)</i>	<i>Agriculture GDP (current US\$)</i>	<i>Agriculture value added (% of GDP)</i>	<i>Agriculture value added per worker (constant 2010 US\$)</i>	<i>GDP per person employed (constant 2017 PPP \$)</i>	<i>GDP per capita (current US\$)</i>	<i>Employment in agriculture</i>
Nation's GDP (current US\$)	1.000						
Agriculture GDP (current US\$)	0.947	1.000					
Agriculture value added (% of GDP)	-0.641	-0.364	1.000				
Agriculture value added per worker (constant 2010 US\$)	0.077	-0.165	-0.649	1.000			
GDP per person employed (constant 2017 PPP \$)	0.430	0.151	-0.890	0.865	1.000		
GDP per capita (current US\$)	0.883	0.920	-0.347	-0.377	0.047	1.000	
Employment in agriculture	-0.592	-0.374	0.799	-0.376	-0.764	-0.474	1.000

The Pearson correlation matrix describes the relationship among variables parameters. The study shows that there is a strong positive correlation between the employment in agricultural sector and Agriculture value added (USD). With correlation coefficient of 0.799, it clearly signifies that increase in agriculture labour force consequently leads to rise in Agriculture value added (USD). On the other hand, GDP per capita (current US\$) and other variables studied are negatively correlated with employment in agriculture. This implies that status of the labour force in the agriculture sector is insignificant to the positive growth of variable indicator (Nation's GDP (current US\$), Agriculture GDP (current US\$), Agriculture value added per worker (constant 2010 US\$), GDP per person employed (constant 2017 PPP \$) and GDP per capita (current US\$) since they are all negatively correlated with employment in agriculture).

Conclusion

The Agricultural sector has remained a significant contributor to the Nigerian economy in terms of employment generation and national output. As such, there is need to effectively and optimally harness the potentials domiciled to maximize its contribution to the growth of the nation's economy.

Although sustaining the major role agriculture plays in providing jobs for huge percentage of Nigeria labour force, there is also need for adoption of improved technology and modern facilities for proper agricultural development in Nigeria.

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References

- Bola, O 2007, *Nigeria Agricultural Sector Oxford University Press Central Bank of Nigeria 2007, Statistical Bulletin vol 18, pp 132-149.*
- Datt, G & Ravallion, M 1998, "Farm Productivity and Rural Poverty in India" *Journal Development Studies*, 34:62-85

- Dowrick, S & Gemmell, N 1991, "Industrial catching up and economic growth: a comparative study across the world's capitalist economies" *Economic Journal* 101:263-276.
- Eicher, C & Witt, L (eds.) 1964, *Agriculture in Economic Development* New York: McGraw Hill, London.
- Ekpo, A & Egwaikhide, F 1994, *Exports and Economic growth in Nigeria: A Reconsideration of the evidence: Journal of Economic Management*, 1 (1): 100-115
- Federal bureau of statistics bulleting 2020; federal department of fisheries, 2015
- Gollin, D, Parente, SL & Rogerson R 2002, "The role of agriculture in development" *American Economic Review* 92(2): 160-164
- Manufacturing Sector Report, 2015: *Manufacturing in Africa* (PDF). KPMG. 2015. Archived from the original (PDF) on 27 September 2016. Retrieved 18 November 2016
- "Nigeria Economy". nigeria-consulate-frankfurt.de. Retrieved 28 May 2020.
- Nigeria | Data; "data.worldbank.org. Retrieved 2021.
- Oji-Okoro Izuchukwu, 2011: *Analysis of the Contribution of Agricultural Sector on the Nigerian Economic Development; World Review of Business Research* Vol. 1. No. 1. March 2011. Pp. 191 – 200
- O. Olukunle. 2013, *Evaluation of income and employment generation from Cassava value chain in the Nigerian agricultural sector, Economics Asian journal of agriculture and rural development*, 2013
- UPDATE Nigeria Government Debt: % of GDP". Retrieved 9 September 2019. agricultural inputs, and the implementation of more productive practices.

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Socio-Economic Status of Fisherfolks and Fishing Activities in Dutsin-Ma Reservoir, Katsina State, Nigeria

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Abstract

Proper understanding of the characteristics and constraints of the artisanal fisheries can help to boost domestic fish production, therefore periodic study of artisanal fisheries in various water bodies in the country may be a strategy towards improved fish production. This study therefore aimed at studying the socio-economic status, fishing activities and constrained faced by artisanal fisherfolks in Dutsin-Ma, Katsina State, Nigeria. A 3-section structured questionnaire was administered to all the regular fishermen on the reservoir and the data obtained were analyzed using descriptive statistics, frequency count and percentage. All the fishermen were male with majority (60%) in active age below 40 years. Only 30% of them had no formal education and the least years of fishing experience among the fishermen was 15 years. Majority had monthly fishing income between ₦ 25000 – 34000. All the respondents were fully engaged in fishing, while 60% of them combined some other things with fishing. Gillnet is the major fishing gear, and it is used in combination with either cast-net or Malian trap by different respondents. There are various constraints facing the fisherfolks, however, access to capital, low fish population and costly fishing materials were regarded as severe constraints by the majority of the fisherfolks.

Keywords: Artisanal fisheries, Dutsin-Ma reservoir, fishing gear, fishing crafts, Tilapia, Clarias.

Introduction

Fish is an integral component of human diet and the needs keep increasing as the population of the world increases (Dauda and Yakubu, 2013). It is a cheap source of animal protein, and contributes a substantial amount to protein consumes globally, especially in coastal and riverine areas. In Nigeria, fish is noted to be contributing up to half of animal protein consumed (FDF, 2009), although the amount contributed widely varies between northern and southern part of the country. While fish production in Nigeria keeps growing, the country is still a net importer of fish despite its large abundant water resources (Dauda *et al.*, 2018). Inadequate management, overexploitation and other factors are being blamed for the decline in the country's fisheries resources. However, improvement and sustainability of these resources will be possible if adequate knowledge of species composition, diversity and relative abundance of the fisheries resources in the water bodies is understood (Adaka *et al.*, 2016).

Fish production in Nigeria has grown from 684,575 metric tonnes in 2007 to 1,123,011 metric tonnes in 2014, although there was a little drop to 1,027,058 metric tonnes in 2015 (FDF, 2008, NBS, 2017). Artisanal fisheries is responsible for 759,828 metric tonnes in 2014 and 694,867 metric tonnes in 2015 (NBS, 2017), representing over 65% of total domestic fish production in the consecutive years. This further confirms how important is artisanal fisheries to fish production not only in Nigeria but also many developing countries of the world.

Artisanal fisheries has been defined by several authors, as generally characterised with the use of simple fishing gears such as simple cast nets, hook and line, gillnets, beach seine, traps etc. The fishing crafts ranges from paddles canoes, gourds and limited engine motorized boats (Dada, 2004). It has little or no opportunities for expansion, it involves low level of technology, lack of modern equipment and low fund to expand (Akanni 2008). Considering the important position occupied by artisanal fisheries, there should be more interest in the socio-economic and well-being of artisanal fisherfolks who are the drivers of the highly important sector of the domestic fish production.

According to Dasuki *et al.* (2014), proper understanding of the characteristics and constraints of artisanal fisheries can help to boost domestic fish production in Nigeria. This may involve periodic study of various water bodies in the country, understanding the characteristics and needs for the fisherfolks as well as making available relevant programmes that can enhance their productivity and that of the water bodies. This research was carried out to investigate the socio-economic status of the fisherfolks, fishing activities and constraints faced by the artisanal fisherfolks in Dutsin-Ma reservoir.

Material and methods

The Study area

The research was carried out at the landing site of Dutsin-Ma reservoir in Dutsin-Ma local government area, Katsina State. The reservoir is located on latitude 12°28' 0.7" N and longitude 7°29'56"E with perimeter of 5.05 km and covered an area of 1.10 square kilometers, Figure 1. The region experiences wet/rainy season and dry season. The rainy season last from June to September with annual rain fall range of 1500--1800 (Dasuki *et al.*, 2014). The reservoir was constructed primarily for domestic water supply in 1974. It is only fed during the rainy seasons by three main sources: Korama from the Western side, Darawa-Korama from the Eastern side, Hadari-Korama, and Surface run off from the surrounding catchment areas during the rainy season. It drained through the main control overflow structure towards Dantsido and through uncontrolled Channel by the western axis. The reservoir has only one landing site where all catches were landed.



Figure 1: Satellite image of Dutsin-Ma Reservoir Katsina State

Data collection

Data on socio-economic status, fishing activities and constraints faced by fisherfolks on the reservoir were collected using 3-sections well structured questionnaires. Being a relatively small water body with a few fishermen, only the regular fishermen were interviewed for reliability of the data and they were ten in number.

Data analysis

The data on socio-economic status and fishing activities were analysed using descriptive statistics, frequency count and percentage, all the analysis was done with IBM SPSS 22.

Results and Discussion

Socio-economic Status of the artisanal fisherfolks in Dutsin-Ma reservoir

Results of the socio-economic status of fisherfolks in Dutsin-ma reservoir is shown in table 1. The fisherfolks in the study area were all (100%) males, this result is similar to the findings of (Dasukiet *al.*, 2014). This can be attributed to the thought risk associated with artisanal fishing and the peculiar culture in the region where females are mostly indoor (Dauda *et al.*, 2013). The age range of the respondents were between 20 and 49 years, with majority (60%) of them still in very active age below 40 years. This means the reservoir provides employment, especially for the youth in the study area, buttressing the observation by many authors that artisanal fishery sector provides employment (Oladoja and Adeokun, 2009). The study revealed that majority (80%) of the fisherfolks in the study area were married with family size that ranges from 12 to 31. The high number of dependent recorded in this study confirmed the report of Ladu *et al.* (2013) who noted that high percentage population depends on fishing. The artisanal fisherfolks of Dutsin-Ma reservoir were educated as majority (70%) of the fisherfolks in the study area had formal education. They are also highly experienced with fishing with minimum of 15 years experience among the respondents. Majority (60%) of the respondents from the study area diversified their income, this can be viewed as a strategy to augment their income in other to reduce poverty. Only 40% of the respondents has no other source of income but fishing which was attributed to lack of capital. Monthly income from fishing activities is between ₦25,000-34,000 per month for the majority (50%) of the respondents. On average the monthly income of fisherfolks

in the study area could be similar to that of their counterpart in the government who earned a minimum wage of ₦30,000 a month. This further strengthened the importance of the reservoir as a reliable source of employment and income (Ladu *et al.*, 2013). The respondents had various annual income from other activities, ranging between ₦20,000 and 50,000, 40% of the respondents earned between ₦30,000 and 49,000 annually from other activities. Average total income from both fishing and other activities can still be regarded to be very low for majority of the fisherfolks, especially if the average number of dependants is put into consideration. The observation in the Dutsin-ma reservoir is similar to that of Oladoja and Adeokun (2009) who regarded poverty as a major constraint to the development of artisanal fisheries in Nigeria.

Table 1: Socio-economic Status of Artisanal fisher folks in Dutsin-Ma Reservoir, Katsina State

Socio-demographic variables	Frequency	Percentage
Gender		
Male	10	100
Female	-	-
Total	10	100
Age		
20-29	1	10
30-39	5	50
40-49	4	40
50 and above	-	-
Total	10	100
Marital status		
Single	2	20
Married	8	80
Total	10	100
Family size		
12-15	1	10
16-19	3	30
20-23	3	30
21-27	2	20
28-31	1	10
Total	10	100
Academic qualification		
No Schooling	3	30
Apprenticeship Training	-	-
Primary School	5	50
SSCE	2	20
Diploma	-	-
Total	10	100
Years of Fishing Experience		
15-19	5	50
20-24	2	20
25-29	2	20
30 and above	1	10
Total	10	100
Diversification of income		
Fishing majorly	4	40
Fishing and other activities	6	60
Total	10	100
Monthly Income from Fishing (₦)		
15000 - 24000	2	20
25000 - 34000	5	50
35000 - 44000	2	20
45000 - 54000	-	-
50000 and above	1	10
Total	10	100
Annual income from other activities (₦)		
20000 - 29000		
30000 - 39000	1	16.7
40000 - 49000	2	33.3
50000 and above	2	33.3
Total	1	16.7
	6	100

Fishing activities, fishing gears and crafts used by artisanal fisher folks in Dutsin-Ma reservoir

As shown in table 2, 40% of the respondents are full time fisherfolks, while majority (60%) of them declined to be regarded as part time fisherfolks but preferred to be reported as engaged in, fishing and farming (40%), fishing and poultry business (10%) and fishing and mining (10%). All respondents in the study area have more than one type of fishing gear but noted that season and water level determined their employment of a particular gear for better catch, majority (80%) of the fisherfolks use various gear combination as a technique to increase catch and boost their income. However, 10% of the respondent used only gillnets during the study period, 60% of the respondents used combination of gillnets and cast-net frequently. Those who used cast-net only were just 10%, while a combination of Malian traps and cast-net recorded 20% usage. The results in Dutsin-Ma reservoir is contrary to that of Zobe reservoir, a larger water body within the same Local government area where Dasuki *et al.*, (2014) reported hook and line as the dominant fishing gear. Although the use of cast net and Malian trap is common to the two water bodies. The gillnet is the dominant gear in the reservoir and all the fisherfolks were using monofilament gillnets. Majority (80%) of the respondents were using between half (1/2) inch and one (1) inch monofilament gillnets. Only 20% of the respondents used monofilament gillnets of two (2) inches, while three (3) inches monofilament gillnets were never employed during the study period. This findings support reports by various authors who observed low compliance to fishing regulations by fisher folks in Nigeria. Enaikele and Olutayo (2010) reported low compliance to fishing regulations in Lagos State, Enyenihi (1990) reported the wrong use of fishing gears in many inland waters of Nigeria such as nets of very small mesh sizes to catch fish as being a method of destabilizing the aquatic ecosystems. Only gourds were used in the study area as fishing craft during the study period, this may be associated to the small size of the reservoir and financial strength of the fisherfolks, which further confirms that artisanal fisher are characterised with low income and simple fishing tools (Coates, 2000; Oladoja and Adeokun, 2009). Tilapia, *Clarias* and *Labeo* species were the species caught during the study period. However, all the respondents noted Cichlids and *Clarias* as their major targeted species.

Table 2: Fishing activities, gears and crafts used in Dutsin-Ma reservoir, Katsina State

Parameters	Frequency	Percentage
Fishing activity status		
Full time	4	40
Fishing and farming	4	40
Fishing and poultry	1	10
Fishing and mining	1	10
Total	10	100
Fishing gears used		
Gillnet only	1	10
Cast-net only	1	10
Gillnet and Cast-net	6	60
Gillnet and Malian trap	2	20
Total	10	100
Mesh size/type of gill net used		
Half inch/monofilament		
One inch/monofilament	4	40
Two inches/monofilament	4	40
Three inches and above	2	20
Total	10	100
Fishing craft used		
Gourd	10	100
Total	10	100
Species of fish caught		
Tilapia, <i>Clarias</i> and carps	10	100
Total	10	100
Two major species caught		
Tilapia and <i>Clarias</i>	10	100

Constraints Faced by Artisanal Fisherfolks in Dutsin-Ma Reservoir Katsina State

Analysis of constraints to artisanal fishing in Dutsin-Ma reservoir (Table 3), revealed that lack of access to capital is a constraint to the fisherfolks, 60% of the fisherfolks agree to this but only 40% noted it as very severe, while 20% noted it as severe, this is similar to the reports of Omorinkoba *et al.* (2011). However, 40% of the fisherfolks responded contrarily to lack of capital as not a constraint, this could be attributed to diversification of income by fisherfolks who were engaged in other income earning activities to augment their income. Low fish population is also a constraint in the study area, 100% of the respondents noted it as constraint in a 50%:50% ratio between very severe and severe constraint. The low fish population can be attributed to unregulated and unsustainable fishing activities over time (Ladu *et al.*, 2013; Neiland *et al.*, 2013). The respondents did not see water pollution as a constraint to fishing activities in Dutsin-Ma reservoir. Poor fishing equipment is a constraint in the study area, this can may be due to lack of capital, 70% respondents noted it as severe constraint. This can be attributed to lack of capital that is characteristically associated with artisanal fishery production in Nigerian inland waters (Oladoja and Adeokun, 2009). Lack of fishing skills is not a constraint in the study area. Government restriction on fishing activities is not also a constraint in the study area. The result is in line with other research findings from similar water bodies across Nigeria (Azionu *et al.* 2014; Eyo and Ahmed, 2005). Poor demand for fish is not noted as a constraint, this implies that fish demand in the study area is more than supply just like many other places in the country, this is in line with the observation of Tsadu *et al.* (2006) and Ibrahim *et al.* (2009). Poor fish price is also not a constraint, 100% of the Fisherfolks interviewed were in agreement to this. This can be attributed to the high demand which may have ultimately transformed to better pricing (Ita, 1993). Costly fishing materials is reported as a very severe constraint by 70% of the respondents. This could be attributed to low investment in artisanal fisheries. Poor marketing system and glut are not regarded as constraints, what is caught is immediately sold, this can be attributed to either high demand earlier reported in this study or might be due to low catch as a result of low fish population in the reservoir. Inadequate storage facility is not also a constraint, this can be attributed to high demand or low catch both of which may not result to a need for storage facilities. The observation in Dutsin-Ma reservoir is contrary to report of Enim (2012) that characterized artisanal fisheries as lack of processing and preservation facilities leading to post-harvest losses. Primitive preservative method was not a constraint to fisher folks in the study area, 80% of the respondents agreed to this, the same reason given for lack of processing applied here. This study revealed that there is high demand for fish, meaning that what is caught is immediately sold leaving nothing to preserve. Proliferation of aquatic weeds is also not a constraint to fishing activities in the reservoir as 90% of the respondents reported it as not a constraint.

TABLE 3: Constraints Faced by Artisanal Fisherfolks in Dutsin-Ma Reservoir Katsina State

VARIABLE	Very severe (%)	Severe (%)	Not a Constraint (%)
Lack of access to capital	4 (40)	2 (20)	4 (40)
Low fish population	5 (50)	5 (50)	—
Pollution of water body	—	—	10 (100)
Poor fishing equipment	—	7 (70)	3 (30)
Lack of fishing skills	—	—	10 (100)
Government restriction on fishing	—	—	10 (100)
Poor demand	—	—	10 (100)
Poor fish pricing	—	—	10 (100)
Costly fishing materials	7 (70)	1 (10)	2 (20)
Poor marketing system	—	—	10 (100)
Glut	—	—	10 (100)
Inadequate storage facilities	1 (10)	3 (30)	6 (60)
Primitive preservative method	—	2 (20)	8 (80)
Proliferation of aquatic weeds	—	1 (10)	9 (90)

Conclusion

The results of the research established that the artisanal fisherfolks of Dutsin-Ma reservoir are though very few but relied on the catch from the reservoir for their sustenance. It is generally characterised with low income and primitive fishing tools, as gourd was the only fishing craft in use. The major fish species being caught were Tilapia, Clarias

and Carps. The major constraints faced by the artisanal fisherfolks and classified as very severe constraints among the majority of them are access to capital, low fish population and costly fishing materials.

References

- Adaka, G. S., Udoh, J. P. and Onyeukwu, D. C. (2014). Freshwater fish diversity of a tropical rainforest River in Southeast Nigeria. *Advances in Life Science and Technology* 24, 16-23.
- Akanni, K.A. (2008). Catch Levels and Capital Investment of Artisanal Fishermen in Lagos State, Nigeria. *Turkish Journal of Fisheries and Aquatic Sciences* 8: 361-368.
- Azionu, B.C., Ovie, S.I., Adigun, B. and Atribom B.Y.(2005). Prospects and Problems of Nigerian Inland Capture Fisheries: the Dimension of Sustainability. Fisheries Society of Nigeria, Book of Abstract. pp. 49.
- Coates, D. (2000). Inland fisheries and enhancement status. Constraints and prospects for food security In kyoto conference outcome and abstracts of papers presented. www.fao.org/waicent/faoinfo/fishery.htm.
- Dada, B. F. (2004). Contribution of fisheries to employment, National Economy and foodsecurity in Nigeria. Paper presented at the 2003 FISON public lecture Lagos. 22nd December 2003. Fish Network 1 (1) 1-6.
- Dasuki, A., Dauda, A.B., Oshoke, J.O., Tiri, G.D. and Bichi, A.H. (2014). A Survey Of Artisanal Fisheries of Makera Zone of Zobe Reservoir, Katsina State. In: Proceedings, 29th Annual Conference of Fisheries Society of Nigeria (Fison), held between 24th – 29th November 2014 at Royal Choice Inn Ltd, Gondo Aluor Road, Old GRA, Lobi Quarters, Makurdi, Benue State Nigeria. Pp 2-5
- Dauda, A.B., Yakubu S.O. and Kabir, I. (2013). Determinants of Fish Consumption in Dutsin-Ma LGA, Katsina State. In : J.A. Adediran, J.O. Saka, A.G. Ibrahim, V.A. Adeyemi, A.O. Atere and M.O. Adenekan (eds). Revamping Nigeria Agriculture through Transformation Agenda: The Way Forward. Proceedings of the 47th Annual Conference of the Agricultural Society of Nigeria held at the Federal College of Animal Health And Production Technology, Moor Plantation, Ibadan, Oyo State, Nigeria 4th – 8th November, 2013. Pp 1106-1109.
- Dauda, A.B and Yakubu, S.O. (2013). Fish Consumption pattern and Knowledge of Fish farming among Inhabitants of Dutsin-Ma LGA, Katsina State. *Nigerian Journal of Fisheries* 10: 586- 594
- Dauda, A.B., Natrah, I., Karim, M., Kamarudin, M.S. and Bichi, A.H. (2018). African Catfish Aquaculture in Malaysia and Nigeria: Status, Trends and Prospects. *Fisheries and Aquaculture Journal* 2018, 9:1 DOI: 10.4172/2150-3508.1000237
- Enaikelé, M.D., Olutayo, A.D. (2010). Explorative Analysis of the Effects of Inland Fisheries Decree on Sustainable exploitation of Inland Fisheries in Lagos State, *Nigeria Journal of Agricultural Extension and Rural Development* 8(1): 154-160.
- Enim UI (2012) What Concerns Nigerian Fisherfolks with Climate? Current Issues in Sustainable Tropical Agriculture. Faculty of Agriculture, University of Uyo, Nigeria 1: 1-13.
- Enyenihi, U.K. (1990). Biological Conservation for Environmental Stability and Food Production. Trans. Nigeria Society of Biological Conservation 1: 4-10.
- Eyo, A.A. and Ahmed, Y.B. (2005). Management of Inland Capture Fisheries and Challenges to Fish Production in Nigeria. Federal College of Freshwater Fisheries Technology, New-Bussa, Nigeria, pp. 624-634.
- FDF (2008). Fisheries Statistics of Nigeria, fourth edition (1995-2007). Publication of Federal Department of Fisheries, Abuja, Nigeria.
- FDF (2009). Nigeria National Aquaculture Strategy Assisted by FAO. Federal Department of Fisheries, Abuja Nigeria 19pp.
- Ibrahim, B. U., Auta, J. and Balogun, J. K. (2009). A survey of the Artisanal Fisheries of Kontagora Reservoir, Niger State, Nigeria. *Bayero Journal of Pure and Applied Sciences* 2(1): 47-51.
- Ita, E.O. (1993). Inland Fisheries Resources of Nigeria. FAO, CIFA Occasional Paper No. 20, Rome, Italy. FAO. pp 120.
- Ladu, B.M.M., Sogbesan, A.O. and Tafida, A.A. (2013) Fisheries and Fishing Enterprises in the Hadeja Jama are Komadugu Yobe Basin, Nigeria. Technical Report, Hadeja Jama are Yobe Basin-Trust Fund, Nigeria.
- NBS (2017). Nigeria's fish production: 2010 – 2015. National Bureau of Statistics, Abuja, Nigeria. 22pp
- Neiland, A.E., Bene, C., Jolley, T., Ladu, B.M.B., Ovie, S, et al. (2002) Fisheries of the Lake Chad Basin; an update on current knowledge and development. In: Neiland AE, Bene C (Eds.), Sustainable Development of African Commercial Fisheries: a regional study of policy options and policy formation Mechanism in the Lake Chad Basin. Final Report, European Commission INCO Project No. ERD1C118CT980331.

- Nwabeze, G.O. and Erie, A.P. (2013) Artisanal Fisherfolks use of sustainable fisheries management practices in the Jebba lale Basin, Nigeria. *Journal of Agricultural Extension* 17(1), 123 -134.
- Odo, G.K., Nwani, C.D. and Eyo, J.E.(2009). The fish fauna of Anambra River Basin, Mageroa Species abundance and morphometry. *Revista de Biología Tropical* 57 (1-2): 177-186
- Omorinkoba, W.S., Ogunfowara, O.O., Aga, N.D. and Mshelia, M.B. (2011).Artisanal Fisheries Activities in Lake Kainji. In: Raji AA, Okaeme N, Ibeun MO (Eds.), Forty Years on Lake Kainji Fisheries Research pp. 43-53.
- Oladoja, M.A. and Adekun, O.A. (2009). Analysis of socio-economic constraints of fisherfolks on poverty alleviation in Lagos State. *Agricultural Journals*, 4(3): 130-134.
- Tsadu, S.M., Ojutiku, R.O and Ayanwale, A.V. (2006). A survey of fungal contamination of some fish species from Tagwai Daru, Minna, Niger State, Nigeria. *Journalof Tropical Biosciences* 6: 1-5.

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Effect of Rice-Fish Farming on Food Security and Livelihood Sustainability in Nigeria: A Review

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Abstract

Nigeria has a great potential for successful rice-fish farming with abundance of millions of hectares of irrigated and swampy rice areas. This has the capacity to contribute significantly in providing food/nutrition security, income and livelihood sustainability predominantly those of the riparian communities. In spite of these significant contributions, the agricultural sector is faced with enormous challenges such as decreasing yield, inadequate technical/commercial knowledge among others. The demand for rice and fish is persistently on the increase with about four million people being added to the population. Though, integrated rice and fish farming can proffer remedy to this lingering problem by playing a vital role in national economy through increased food production, income and livelihood sustainability. Rice-fish farming is considered to lower the risk of production which may provide strong drive for livelihood diversification and sustainability. This study reviewed the effects of rice-fish farming on food security and livelihood sustainability in Nigeria. It was revealed that food security, poverty alleviation and socio-economic growth in Nigeria can be enhanced by the adoption of integrated rice-fish farming.

Keywords: Rice-fish, farming, food security and livelihood

Introduction

Availability of food is one of the leading challenges facing the world (including Nigeria). Rice and fish abundance remain critical issues in Nigeria food and nutrition security. In order to achieve abundant food supply to meet the increasing demand for food in Nigeria, there is a need for increased rice and fish production. Miller *et al.*, (2006) concluded that since Nigeria has about 2 million hectares of irrigated and swampy rice areas, there is great potential for successful rice-fish farming. Rice-fish farming involves the growing of rice and fish concurrently or rotationally in the same compartments. It can also be done by growing rice and fish in separate compartments, using the same water as reported by Halwart and Gupta (2004). In Africa and some Latin American countries it is operated at small scale. Fishes usually cultured in rice fields in Africa is the *Tilapia* sp. (*O. niloticus* and *O. mossambicus*), *Clarias* and Carp sp. Nnaji (2012) asserted that in Egypt, fish production from rice-fish farming accounted for 32% of the total fish production from aquaculture in 1995. He further reported that in Madagascar, about 1,100 tons of fish were produced as at 1995 from about 13,500 ha of rice farms under FAO/UNDP assistance.

In Nigeria, considering the huge potential of 2 million hectares of irrigated and swampy rice areas, the adoption of rice-fish farming could lead to increase food production. Therefore, there is a need for livelihood diversification in rice-fish integration. Such farm diversification will enhance food security and livelihood sustainability. Rice monoculture cannot alone provide a sustainable food supply, while integrated rice-fish farming is considered to remain the best in terms of resource utilization, productivity and food supply (Omitoyin, 2014). The broad objective of this paper is to examine the impact of rice-fish farming on food security and livelihood sustainability.

Impact of rice-fish farming on food security

Poverty, hunger, malnutrition and deprivation are some of the important challenges facing Nigeria and other developing countries despite its huge human and natural endowment (Defoer *et al.*, 2004; Alamu, 2004). In the face of prevalent economic downturn, vast majority of the rural poor are more adversely affected by food and nutrition insecurity. An alternative approach to enhance food security becomes imperative. Study report by Nnaji (2012) confirmed that food security, poverty alleviation and socio-economic growth in Africa (Nigeria inclusive) can be enhanced by the adoption of integrated aquaculture farming system (rice fish farming). Rice is an important cereal in Nigeria and is largely consumed across the ethnic groups in the country with an annual importation bill of ₦365

billion out of which about ₦1billion is used per day (Akinwumi, 2013) whereas; annual national fish production is about 1.1 metric ton out of a huge demand of 3.2million metric tons (FDF, 2016). It was also reported that in Nigeria, the demand for rice and fish is persistently on the increase with about four million people being added to the population. However, integrated rice and fish farming can proffers remedy to this lingering problem by playing a vital role in national economy through:

- Adequate supply of carbohydrate and also fish protein which is confirmed to be cheapest sources of animal protein rich in micronutrients and vitamins, thus food and nutrition security is assured.
- The production of various food (rice and fish) all year round
- Increasing sources of income and subsequently augment farmers disposable income on other food sources

Enhancement in the local community's nutrition has been cited as one of the benefits of rice-fish farming. With greater availability of fish, the rural population of a rice farming community will have easy access to fish at affordable prices. On the other hand, in rural areas of Philippines where culture and capture fisheries is practiced, it is confirmed that fish and other aquatic organisms from rice fields provide a very important component of the daily diet (Halwart and Gupta, 2004).

Impact of rice-fish farming on livelihood sustainability

Rice-fish farming contributes to the livelihood sustainability of small and large scale farmers through improved food supply, employment and income generation. A livelihood comprises the assets (natural, physical, human, financial and social capital) and access to assets that together determine the living gained by the individual or household. The concept of 'a livelihood' seeks to bring together the critical factors that determine the well-being of individuals or family. The immediate beneficiaries of rice-fish farming are the farmers who adopt the technology. The impact of rice-fish farming to livelihood sustainability has been demonstrated in some countries. In northern Nigeria, it was reported by Nnaji (2010) that adoption of rice -fish farming technology in plot area of 144m² can generate a net income of ₦6,396.00 compared to ₦2,250.00 net income obtained from a mono- rice of the same plot area. In other countries, Halwart and Gupta (2004), reported that in Guimba, Ecija and Philippines, the adoption of 2.3 ha of rice-fish farm technology can generate additional 23% more farm income by raising fish as well in 0.5ha.

Rice-fish farming is considered to lower the risk of production which may provide strong drive for livelihood diversification and sustainability. Integration of rice alongside fish farming was reported by Frei and Becker (2005) to optimization of resources utilisation through the harmonization of natural resources (including land and water), improves livelihood diversification, livelihood outcomes; intensification, output, profitability and sustainability (Ahmed *et al.*, 2007). A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base (see fig 1). Therefore, the impact of rice-fish farming on livelihood sustainability largely depends on its potentials to:

- Opts for the best use of natural assets as functional inputs. This is achieved by combining natural and regenerative processes, such as nutrient cycling, nitrogen fixation, soil regeneration and natural enemies of pests with food production processes.
- Minimizes the use of nonrenewable inputs (pesticides and fertilizers) that damage the environment or harm the health of farmers and consumers.
- Makes better use of the knowledge and skills of farmers, thus improving their self-reliance.
- Seeks to make productive use of social capital - people's capacities to work together to solve common management problems, such as pest, watershed, irrigation and credit management (Pretty and Hine, 2010).

Based on the concept of sustainable livelihood, it can be further expatiated that rice fish impact positively on livelihood sustainability through:

- Fish improving soil fertility by increasing the availability of nitrogen and phosphorous (Dungan *et al.* , 2006)
- Feeding behaviour of fish in rice field thereby causing aeration of the water
- Fish being regarded as an important element in integrated pest management in rice crops (Halwat and Gupta, 2004)
- Controlling aquatic weeds and algae that carry diseases thereby acting as hosts for pests and also compete with rice for nutrients. Moreover, fish eat flies, snails and insects, and can help to control malaria mosquitoes and water-borne diseases (Matteson, 2000)

- Reducing costs of production due to the interactions between fish and rice, insects and pests are consumed by the fish. On the other hand, rice fields provide fish with planktonic, periphytic and benthic food (Mustow 2002).
- Shading of rice plants which also maintains the water temperature thereby making favorable to fish during the summer (Kunda *et al.*, 2008).

Conclusion

The adoption of rice-fish farming could contribute to reducing the increasing demand for food and enhance livelihood sustainability. This paper concludes that rice fish farming integration remain feasible alternative for livelihood diversification that will enhanced food security through efficient and ecologically sound production system for rice and fish.

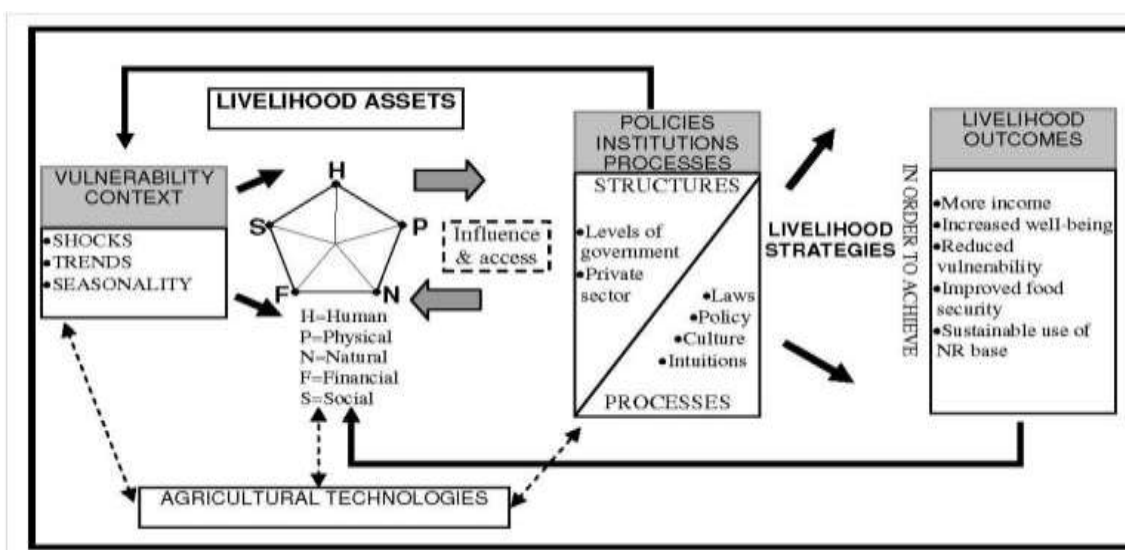


Fig 1: Sustainable livelihood framework modified from Carlos (2000)

References

- Alamu S.O, Abiodun J.A, Miller J.W (2004). Food Security and Poverty Alleviation under the National Special Programme for food security: A. preliminary socio-economic assessment of Yamama Lake, Kebbi State: In P.A Araoye (ed). Proceedings of the 19th Fisheries Society of Nigeria Conference. Pp. 149-162.
- Ahmed, N., Wahab, M. A and Thilsted, S. H. (2007). Integrated aquaculture-agriculture systems in Bangladesh: potential for sustainable livelihoods and nutritional security of the rural poor.
- Akinwumi A (2013). Rice consumption and importation in Nigeria, no solution in sight. Vanguard, December 30th, 2013.
- Carlos, P. (2000). *Sustainable livelihood approach in inland fisheries*. In: Programme PMEDP/SFLP. Cotonou, Republic of Benin, Pp. 28, 33.
- Defoer, T., M.C.S. Wopereis, M.P. Jones, F. Lancon, O. Erenstein and R.G. Guei, 2004. Rice-based production systems for food security and poverty alleviation in sub-Saharan Africa. Proceedings of the FAO Rice Conference, February 12-13, 2004, FAO, Rome, Italy, Pp. 75-84.
- Dugan, P., Dey, M. M and Sugunan, V. V (2006). Fisheries and water productivity in Tropical River Basins: enhancing food security and livelihoods by managing water for fish. *Agricultural Water Management*, Pp. 262–275.
- FDF (2016). Federal Department of Fisheries, Fisheries Statistics of Nigeria Projected human population; fish demand and supply in Nigeria, 2000 – 2015. 56pp.
- Frei, M., & Becker, K. (2005). Integrated rice-fish culture: coupled production saves resources. *Natural Resources Forum*, Pp. 135–143.

- Halwart, M. & Gupta, M. V. (2004). Culture of fish in rice fields. Food and Agriculture Organization of the United Nations and the WorldFish Center, p 83.
- Kunda, M., Azim, M. E., Wahab, M. A., Dewan, S., Roos, N and Thilsted, S. H. (2008). Potential of mixed culture of freshwater prawn (*Macrobrachium rosenbergii*) and self recruiting small species mola (*Amblypharyngo don mola*) in rotational rice-fish/prawn culture systems in Bangladesh. Aquaculture Research, Pp. 506–517.
- Matteson, P. C. (2000). Insect-pest management in tropical Asian irrigated rice fields. Annual Review Entomology, Pp 549–574.
- Miller, J., T. Atanda, G. Asala and W.H. Chen (2006). Integrated irrigation-aquaculture opportunities in Nigeria: The special programme for food security and rice-fish farming in Nigeria. FAO-National Special Programme for Food Security Office, Abuja, Nigeria.
- Mustow, S. E (2002). The effects of shading on phytoplankton photosynthesis in rice-fish fields in Bangladesh. Agriculture, Ecosystems and Environment, Pp.89–96.
- Nnaji, J.C, Madu, C.T and Raji A (2012). Profitability of rice fish farming in Bida, North Central Nigeria. Journal of fisheries and Aquatic Sciences, Vol 8, Pp.148-152
- Nnaji, J.C (2010). Integrated rice cum fish farming. National Institute for Freshwater Fisheries Research, Extension Guide series 12. Pp. 11-12
- Omitoyin, B.O (2014). Production method and systems of integrated aquaculture. Paper presented at training workshop on integrated aquaculture system held 8th-11th December, 2014 at NIFFR Monai Adopted Village New Bussa, Niger state.
- Pretty, J and Hine, R (2010). Reducing food poverty with sustainable agriculture: A summary of new evidence. Centre for Environment and Society, University of Essex, Wivenhoe Park, Colchester CO4 3SQ, UK. p10

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Schooling Status And Future Participation In Post-Harvest Fishing Activities Among Senior Secondary School Students In Coastal Communities In Ibeju-Lekki Lagos State, Nigeria

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Abstract

This study investigated the effect of schooling status on future participation in post-harvest fishing activities in the selected coastal communities of Ibeju-Lekki in Lagos State. In specific term, the study attempted to understand whether significant number of the students will embrace post-harvest fishing activities in future as an occupation after their education. The study adopted a non-experimental research design and cross-sectional survey method. Multi-stage sampling technique was adopted to select three out of the five major fishing communities in the area. Quantitative data were generated through the use of a set of structured questionnaires and analyzed using regression analysis as well as descriptive statistics. The study revealed that schooling status was a significant predictor of future participation in post-harvest fishing activities among secondary school students in the three selected fishing communities of Ibeju-Lekki. It was, therefore, recommended that policies on the fisheries sub-sector need to be improved to address some demotivating factors like dearth of effective communication between the government, artisanal fishers and fishing communities and that credit facility should be made accessible to fisher folks so that they will be able to acquire necessary tools which are of good quality and cost-effective among others.

Keywords: Schooling Status, Participation, Fishing, Communities, Lagos Stat

Introduction

Fishing, as one of the major economic activities of man (Benson et al, 2018), has assisted human beings in terms of aquatic food supplies, employment generation and increase in income as well as improvement in the health of people of coastal areas who largely derive their livelihoods from fishing and associated post-harvest activities (Allison et al., 2009). Food and Agriculture Organization (FAO) (2018) revealed that a total of 90.9 million tonnes of fish were captured in 2016 alone across the globe. Furthermore, in Nigeria, where there are many river networks and ocean waters (Benson et al, 2018), over 90 percent of the total annual fish production is derived from capture fisheries, while 6.06 percent of the total fish production in the country results from culture fisheries (Olaoye et al., 2012; NIOMR, 2011; Ozigbo et al., 2014).

Benson and colleagues (2018) revealed that post harvesting activities, such as processing, marketing and distribution, give people in the study area an annual moderate income. This is corroborated by the submission that post harvesting methods which include smoking are crucial to preserving nutritional properties as well as economic value of smoked catfish (Daramola, Kester and Allo, 2013). Okeowo, Bolarinwa and Ibrahim (2015) revealed that most of their respondents in Epe and Badagry respectively earned more than N200, 000 per annum from fishing. The monetary benefits accruing from fishing explains why many families in coastal areas, such as Epe and Badagry, ventured into the fishing business (Okeowo et al., 2015). Other studies have shown that the artisanal fishery business is a profitable venture (Abowei and Hart 2008; and Adewale, A. O. (2008).

In terms of educational attainments of fishers in Lagos coastlines, Benson and colleagues (2018) revealed that majority of fisher folks who participated in their study had attained one form of formal education or the other. Similarly, a study conducted in Eti-Osa and Ibeju-Lekki Local Government Areas of the state has shown that majority of the fishery practitioners who participated in the study had primary school education (49.0%) followed by those with secondary school education (35.4%). Less than 7 percent (6.2%) had attained tertiary education. The study further showed that a sizable number of the respondents (61.5% and 14.6%) were between the ages of 31-40 years and 41-50 years respectively (Oyediran et al., 2016).

These results above give the impression that most people practicing fishery in the Lagos lagoons, such as Ibeju-Lekki and others, are less than 60 years old with an appreciable level of formal education. Therefore, it is expected that such people are not likely to lack the knowledge and information about the importance of adopting new technologies and innovations (Omoare et al, 2013) in their art of fishing. This, however, was not the case when Oyediran and colleagues (2016) revealed poor awareness creation and capacity building to be among the major obstacles against adoption of low-cost fish processing technologies in Eti-Osa and Ibeju-Lekki fishing communities. Others include cost of processing equipment, poor electricity supply, inadequate extension support, lack of technical support, lack of credit facility and flooding (Oyediran et al., 2016).

Objective of the study.

The objective of this study is to examine the effect of schooling status on future participation in post-harvest fishing activities among the senior secondary school students in selected fishing communities in Ibeju-Lekki.

Methodology

Description of the study location

This study was conducted in Ibeju-Lekki area of Lagos state, a south-western state and the economic hub of Nigeria (Filani, 2012). Being the largest urban area in the country, the population of the state was estimated at 14,368,332 (World Population Review, 2020). In the southern part, the state covers about 180 km along the coast of Atlantic Ocean, occupying a landmass area of 3,577 km² 22 percent (786.94 km²) of which are lagoons and creeks (Benson et al, 2018; Oyediran et al., 2016). The aquatic feature of the state has opened the opportunities for varieties of aquatic activities which include productive fishing ventures and other associated commercial activities (Benson et al, 2018).

Ibeju-Lekki is a coastal area with a total population of 117,793 made up of 60,729 males and 57,064 females respectively (National Population Commission, 2006). The area is located between Latitude 6.496267 and Longitude 3.596457 respectively (GPS-coordinates of Ibeju-Lekki). The dominant indigenous economic activities in the area include 'fishing, agriculture, timber /saw-milling, mat/ raffia weaving, oil-palm processing and emerging eco-tourism' (Oyediran et al., 2016).

The study adopted a non-experimental research design and cross-sectional survey method. Data were collected from the respondents using structured questionnaire. The lottery method of the simple random sample was initially used to handpick Ibeju-Lekki Local Council Development Area (LCDA) from the fifty seven local government areas and local council developmental areas of Lagos state. Using the multistage sampling technique, the selected LCDA was divided into five major fishing communities namely, Lakowe, Awoyaya, Eputu, Kajola and Oribanwa.

Operationalization of terms/exclusion criterion

Post-harvest fishing activities: These include processing, marketing and distribution of aquatic outputs (Williams, 2006; Olubango et al., 2007; Benson et al, 2018). Participation, in the current study, is operationalized to include years of participation, days of participation per week and possible future participation in post-harvest fishing activities among the sampled secondary school students in the study area.

Actual current participation was used as an exclusion criterion in selecting the total sample. Therefore, students who have never participated or have stopped participating in post-harvest activities were excluded from the study.

The data collected were analyzed using the Statistical Package for the Social Sciences (SPSS) version 20 and regression analysis was adopted in testing the hypothesis which states as follows.

Hypothesis

Formal schooling status does not significantly determine future participation in post-harvest fishing activities among the senior secondary school students in selected fishing communities in Ibeju-Lekki.

Presentation of descriptive results

Demography of the respondents

Table 1: presenting demographic profile of the respondents

Sex	N= 120 (%)
Male	70 (58.3)
Female	50 (41.7)
Age group	N= 120 (%)
12-14 years	40 (33.3)
15-17 years	53 (44.2)
18 years and above	27 (22.5)
Ethnic group	N= 120 (%)
Yoruba	58 (48.3)
Hausa	9 (7.5)
Igbo	34 (28.3)
Others	19 (15.8)
Religion	N= 120 (%)
Christianity	78 (65.0)
Islam	34 (28.3)
Traditional religion	8 (6.7)
Family type	N= 120 (%)
Single parenthood	12 (10.0)
Monogamous family	73 (60.8)
Polygamous family	35 (29.2)

Table 1 presents demographic information about the respondents. More than 50 per cent male students participated in the study as against female students most of whom did not show interest in the study for reasons better known to them. Students who were between 12 and 14 years participated more in the study (44.2%) followed by those between the age group of 15-17 years. Those that have attained the age of puberty participated less than the other two categories (22.5%). Students from the Yoruba ethnic background recorded highest participation (48.3%) followed by those from the Igbo ethnic group. Table finally revealed that about 61 per cent of the students sampled hailed from monogamous families, while less than 30 per cent (29.2%) of the total sample came from polygamous families.

Participation in post-harvest fishing activities

Table 2: presenting dimensions of participation in post-harvest fishing activities among secondary school students in selected communities in Ibeju-Lekki

Years of participation in post-harvest fishing activities	N= 120 (%)
1-5 years	54 (45.0)
5 years and above	66 (55.0)
Days of participation in post-harvest fishing activities per week	N= 120 (%)
1-3 days	32 (26.7)
3 days and above	88 (73.3)
Post-schooling interest in post-harvest fishing activities	N= 120 (%)
Interested	52 (43.3)
Not interested	68 (56.7)

Table 3: presenting respondents' desire to attend tertiary institutions after secondary school education

Desire to attend university after secondary school	N= 120 (%)
Yes	92 (76.7)
No	28 (23.3)
Reasons for desire to attend tertiary institutions after secondary school	N= 120 (%)
To improve my knowledge	24 (20.0)
To give me higher chances to get employed	37 (30.8)
I want to work in corporate organization	26 (21.7)
To be able to relate well with people	33 (27.5)
Reasons for lack of desire to attend tertiary institutions after secondary school	N= 120 (%)
I want to do business	55 (45.8)
I want to continue my parents' job (fishing)	29 (24.2)
I am not academically sound	14 (11.7)
I want to pursue other career like foot ball	22 (18.3)

Table 4: presenting respondents' preference for formal job to fishing after secondary school education

Preference for formal job to fishing activities after schooling	N= 120 (%)
Yes	86 (71.7)
No	34 (28.3)
Reasons for preferring formal job to fishing activities after schooling	N= 120 (%)
Inaccessibility of low-cost fish processing technologies	7 (5.8)
lack of credit facility to encourage one's career in fishing	11(9.2)
Perception that fishing activities are meant for illiterates	24 (20.0)
The problem of flooding making fishing a seasonal venture	15 (12.5)
Poor government policies on fisheries slowing down the subsector development	21(17.5)
Lack of technical support to enhance artisanal fisher folks' skills and capacities	42 (35.0)
Reasons for preferring fishing to formal job after schooling	N= 120 (%)
Fishing creates job/employment	50 (41.7)
It creates income	34 (28.3)
It is recreational	12 (10.0)
Post-harvest processing like smoking preserves nutritional qualities of fish	8 (6.7)
It is a traditional occupation for my family	16 (13.3)

Table 2 presents dimensions of participation in post-harvest fishing among the respondents. In terms of years of participation, more than half of the sample (55.0%) has been in the business for 5 years and above. This indicates a long participation in post-harvest fishing by many of the sampled secondary school students in the study area. Similarly, majority of the respondents (73.3%) participated in the post-harvest processing for 3 days and more in every week, as against less than 30 per cent who did not record beyond 3 days of participation in a week. This shows the importance of fishing and associated activities to many families in the fishing communities. This finding goes in line with Okeowo and colleagues (2015) who revealed that many families in coastal areas, such as Epe and Badagry, ventured into the fishing business. In contrast, the table reveals that more than half (56.7%) of the respondents lacked interest in further participation in post-harvest activities after their secondary school education.

The reason for lack of interest in the business after the secondary school education is presented in Table 3 where it was revealed that about 77 per cent of the respondents registered their desire to attend tertiary institutions after their secondary school. Table 3 further shows that possibilities of getting employed was given by many respondents (30.8%) as a reason for their desire to attend tertiary institution, contrary to other 20 per cent who desired for tertiary education in order to improve in knowledge. Meanwhile, less than 25 per cent lacked desire for tertiary education because they wished to continue fishing because that is what their parents do.

In a similar connection, Table 4 shows that about 72 per cent preferred formal employment to fishing after their secondary education. Perception that fishing generally is meant for illiterates was given by 20 per cent for preferring formal job to fishing. Meanwhile, 35 per cent would like to drop fishing for a formal job because of lack of technical support to enhance the skills and capacities of artisanal fishers. Among those that preferred fishing to formal job, only 10 per cent perceived fisheries as recreational, while less than 14 per cent preferred the business to formal job because it is traditional occupation for their families.

Testing the hypothesis

Table 5: Summary of regression model for predictor of future participation in post-harvest fishing activities among secondary school students in selected fishing areas in Ibeju-Lekki

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.237 ^a	.056	.048	0.42187
a. Predictors: (Constant), Schooling status				

Source: Field Survey, 2019

Discussion of the findings

The regression result showed the predictive ability of schooling status on future participation in post-harvest fishing activities. The R-Square value indicates that .056 i.e. 5.6% of the variance in future participation in post-harvest fishing activities can be predicted from schooling status. The adjusted R-square attempts to yield a more honest value to estimate the R-squared for the population, hence the adjusted R² value of 0.048 i.e. 4.8% shows the actual variation in the future participation in post-harvest fishing activities is due to the change in schooling status. This implies that there are other factors that can predict future participation in post-harvest activities among the sampled students in the selected areas of the study location. Therefore, the Null hypothesis that schooling status does not significantly influence future participation in post-harvest fishing activities is rejected. That is, attaining secondary school education is a significant predictor of future participation in post harvesting in the study area.

This finding was corroborated by Nwaogwugwu&Obele (2017) who argued that majority of the youth who have formal education prefer to take white collar job in industries to engaging in fishing and agriculture in general. It is further corroborated by Ovwigho and Ifie (2009) who submitted that most Nigeria youth lack interest in agriculture despite the fact that developing the sector greatly depends on their participation. However, the finding is in disagreement with Adesina and Favour (2016) who revealed that formal education contributed to youth's interest in agriculture in Ondo state. Similarly, Benson and colleagues (2018) revealed that most of their respondents had acquired formal education, suggesting that such people still continued in their fishing endeavors despite their share of formal education.

Conclusion/Recommendation

The focus of this study was to establish a relationship between schooling status and future participation in post-harvest fishing activities among secondary school students in Ibeju-Lekki area of Lagos state. One reason for this research interest was partly informed by the argument that agricultural progress and development rests largely on youth's participation (Ovwigho and Ifie, 2009). To forestall this possibility, it was recommended that:

1. Policies on the fisheries sub-sector need to be improved to address some de-motivating factors like dearth of effective communication between the government, artisanal fishers and communities where fishing activities take place.
2. Credit facility should be made accessible to fisher folks so that they will be able to acquire necessary tools which are of good quality and cost-effective.
3. Provision of technical support to enhance artisanal fisher folks' skills and capacities.

Reference

- Abowei, J.F.N and Hart, A (2008). Economic Efficiency in Fish Farming: Hope for Agro-Allied Industries in Nigeria. *Chinese Journal of Oceanology and Limnology*, 26(1):104-115.
- Adesina, T. K., & Favour, E. (2016). Determinants of participation in youth-in-agriculture programme in Ondo State, Nigeria. *Journal of Agricultural Extension*, 20(2), 104-117.
- Allison E, Allison P, Marie-Caroline B, Neil Adger W, Katrina B, Declan C, Ashley SH (2009). Vulnerability of national economies to the impacts of climate change on fisheries. *Fish and Fisheries* 10(2):173-196.
- Benson, O., Ambee, I., Akinnigbagbe, O., Omotuyi, B. and Solagbade, A. (2018). Gender roles in fisheries post-harvesting activities in catch-locations within Coastal Areas of Lagos State Nigeria. *Journal of Agricultural Extension and Rural Development*. Vol.10(12), pp. 245-250. DOI: 10.5897/JAERD2018.0980.
- Daramola, J.A., C.T. Kester, and O.O. Allo. (2013). Biochemical Evaluation of Hot-Smoked African Catfish (*Clarias gariepinus*) Sampled from Sango and Ota Markets in Ogun State. *Pacific Journal of Science and Technology*. 14(1):380-386.
- Filani, M. O. (2012). The changing face of Lagos: From vision to reform and transformation. *Report funded by Foundation for Development and Environmental Initiatives (Nigeria), and Cities Alliance*.
- Food and Agriculture Organization (FAO) (2018). The State of World Fisheries and Aquaculture. Food and Agriculture Organisation of the United Nations, Rome, Italy. ISBN: 978-92-5-130562-1
- Ikape, S. I., Solomon, S.G. and Okomoda, V.T. (2015). Present and Anticipated Future Problems Facing the Fisheries Sector in Nigerias and the Ways Forward for Profitable and Sustainable Aquaculture in the Country
- Longitude, latitude, GPS coordinates of Ibeju-Lekki. <https://www.gps-latitude-longitude.com/gps-coordinates-of-ibeju-lekki>
- NIOMR (2011). Annual Report. Nigerian Institute for Oceanography and Marine Research. VI, Lagos Federal Department of Fisheries (FDF), Fisheries Statistics.
- Nwabeze, G. O., & Erie, A. P. (2013). Artisanal Fishers' Use of Sustainable Fisheries Management Practices in the Jebba Lake Basin, Nigeria. *Journal of Agricultural Extension*, 17(1), 123-134.
- Nwaogwugwu, O. N., & Obele, K. N. (2017). Factors limiting youth participation in agriculture-based livelihoods in Eleme Local Government area of the Niger Delta, Nigeria. *Journal of Scientia Agriculture*, 17(3), 105-111.
- Okeowo. T. A., Bolarinwa, J. B. and Ibrahim, D. (2015). Socioeconomic Analysis of Artisanal Fishing and Dominant Fish Species in Lagoon Waters of EPE and Badagry Areas of Lagos State. *International Journal of Research in Agriculture and Forestry Volume 2, Issue 3*. Pp. 38-45.
- Olaoye OJ, Idowu AA, Omoyinmi GAK, Akintayo IA, Odebiyi, OCA Fasina AO (2012). Socio-Economic Analysis of Artisanal Fisher Folks in Ogun Water-Side Local Government Areas of Ogun State, Nigeria. *Global Journal of Science Frontier Research Agriculture and Biology* 12(4):9-22.
- Olubanjo OO, Akinleye SO, Balogun MA (2007). Occupational characteristics, technology use and output determinants among fisher-folks in Ogun Waterside Area, Ogun State. *FAMAN (Farm Mgt Ass. of Nig.) Journal* 8(2):1.
- Omoare AM, Fakoya EO, Abiona BG, Oyediran WO (2013) Fish Marketing: A Panacea towards sustainable agriculture in Ogun State, Nigeria. World Academy of Science, Engineering and Technology (WASET) Conference held at Holiday Inn London - Wembley, London, UK, pp. 439-444.
- Ovwigho, B. O., & Ifie, P. A. (2009). Attitude of Youth to Agricultural Development Programmes in Ughelli South Local Government Area of Delta State, Nigeria. *Journal of Agricultural Extension*, 13(2).
- Oyediran WO, Omoare AM, Oladoyinbo OB, Ajagbe BO, Dick TT (2016). Constraints Limiting the Effective Utilization of Low-Cost Fish Processing Technologies among Women in Selected Fishing Communities of Lagos State, Nigeria. *Fish Aqua J* 7: 185. doi: 10.4172/2150-3508.1000185
- Ozigbo E, Anyadike C, Adegbite O, Kolawole P (2014). Review of Aquaculture Production and Management in Nigeria, *American Journal of Experimental Agriculture* 4(10):1137-1151.

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Aspects Of The Small-Scale Freshwater Fisheries Resources In Bayelsa State**Ansa, E.J.**African Regional Aquaculture Centre of the Nigerian Institute for Oceanography
and Marine Research (ARAC/NIOMR), Aluu, P.M.B. 5122, Port Harcourt, Nigeria.**Abstract**

A survey was conducted in Ogbia, Yenagoa, Southern Ijaw, Kolokuma/Opokuma, Sagbama and Ekeremor Local Government Areas (LGAs) of Bayelsa State. Interviews were conducted, questionnaires were administered, and scoping of existing information was done to obtain baseline information on the status and prospects of the small-scale fisheries industry in these LGAs. The level of gender participation in the fishery business was also studied. The State has a strong small-scale fishery business with subsistence fishing being a common feature among the populace. Consumer preferences and consumption patterns of fish and fish products were also determined. It was observed that consumer preference was mostly influenced by the availability of fish products and not by choice. Fishing festivals and harvesting of traditional earthen ponds are carried out occasionally. In some areas, cultural practices are governed by taboos which enable the indigenes to manage their fisheries sustainably. Short, medium, and long term goals are proposed for the development of the fisheries sector in the State.

Keywords: gender, fisheries management, small-scale fisheries

Introduction

It is known that fishing has been a major source of income for the people of Bayelsa and the activity has served as a provider of employment and economic benefits to many families (Kingdom *et al.*, 2013). It is also known that the World Fisheries sector has developed dynamically in recent years and many nations have taken advantage of the new opportunities by investing in modern fleets for fishing and processing. This increasing activity in the sector has also led to over exploitation of the fishery resources. The fishery resources though renewable are not endless and need to be properly managed to be able to sustain the sectors contribution to the nutritional, economic and social wellbeing of the growing world's population (FAO, 2002). The FAO has thus introduced for voluntary adoption and implementation by all nations the "Code of Conduct for Responsible Fisheries". The Code emphasizes that fishing should be done in a responsible manner for the effective conservation and management of the living aquatic resources and further states that "fisheries management of the living aquatic resources; and further states that "fisheries management should promote the maintenance of the quality, diversity and availability of fishery resources in sufficient quantities for present and future generations in the context of food security, poverty alleviation and sustainable development" (FAO, 1995).

The contribution of small-scale fisheries to the development of the fisheries sector in poverty and hunger reduction cannot be over emphasized and is therefore important in achieving the Sustainable Development Goals. However small-scale fishing communities are usually faced with different challenges, including the depletion and over exploitation of resources, lack of other sources of income, rapid growth of their population, displacement due to industrial developments and/or conflicts, environmental degradation, and pollution (FAO, 2005). The objective of this study therefore is to determine the target fish species, consumer preference, markets, gender involvement, fishing festivals, and taboos that characterize inland small-scale fisheries of Bayelsa State.

Materials and Methods

Household interviews were conducted, questionnaires were administered, and scoping of existing information was done to obtain baseline information on the status and prospects of the small-scale fisheries in six out of eight Local Government Areas (LGAs) namely, Ogbia, Yenagoa, Southern Ijaw, Kolokuma/Opokuma, Sagbama and Ekeremor in Bayelsa State.

Results and Discussion

Target fish species

Bayelsa State has an active artisanal inland small-scale fishery, with several creeks, lakes and rivers. The inland freshwater rivers and creeks are sources of fin and shell fish species. Target fish species include but are not limited to snakehead (*Channa* (= *Ophiocephalus*) *obscura*); *Gymnarchus niloticus*; *Heterotis niloticus*; *Chrysichthys* spp (silver catfish); *Heterobranchius* spp, *Clarias* spp (African catfishes), *Synodontis* spp; *Protopterus annectens* (mudfish), *Mormyrus* spp (Elephant snout fish). Other commercially important fin fish species are highlighted in (Idodo-Umeh, 2003; Olaosebikan and Raji, 2004). The shellfish species include the Niger River prawn or 'opuru' (*Macrobrachium felicinum*); African River prawn or 'agbada' (*M. vollehovenii*); and other freshwater prawn species including *Palaemon elegans*, *Macrobrachium dux* and *M. macrobrachion*; freshwater clam or 'gbou' (*Egeria* (= *Galatea*) *radiata*); other freshwater clams like *Mutela* spp and *Spathopsis* spp and the aquatic apple snail *Pila africana*; and other aquatic gastropods of less economic value e.g. *Lanistes* sp. Other freshwater gastropods of less economic but of significant medical importance being vectors in the transmission of schistosome parasites, such as snails include *Biomphalaria*, and *Bulinus*.

Fishing Gear/Crafts

Survey data showed similar gear is used across the six LGAs for fishing in the inland water bodies. It was observed that there are various types of fishing gear employed by the fisher-folk and different fishing crafts. Fishing gear include bottom set gillnet, cast net, hook and line, long lines, drift gill net, traps – woven traps, funnel mouthed non-return valve traps, spear, and beach seines. This is in consonance with fishing gear of inland water bodies listed in Binyotubo (2019). The fishing craft used is mainly un-motorized dug-out canoes with wooden paddles or bamboo or palm tree leaves shafts.

Fisheries Management Knowledge

From the survey, it was observed that environmental influence, local taboos and beliefs affect management of the fisheries stock in different localities. Environmental influence includes strong winds, torrential rains and high flood levels that hinder activities of fisher-folk at the peak of the rainy season (July to September) along the courses of large rivers. On the contrary fishing activities in the floodplains occur more in the rainy season. This is because due to a rise in water level in the rivers causing the rivers to overflow their banks. Fish follow the inundating water and utilize the floodplains which are usually conducive for breeding and serve as a sanctuary from the strong river currents at this time of the year. There is also sufficient food for the breeders and their young, so the floodplains also serve as a good nursery ground for many fish and freshwater river prawns. The fishers also exploit the fisheries resources in the floodplains during the annual rise of flood waters. This is common in all six Local Government areas studied. Local taboos and beliefs in certain quarters prevent fishing in designated areas for a period, which varies from one year to several years. During this ban on fishing, offenders are usually penalized by the community leaders or *juju* priests. Penalties could be in form of fines paid in cash or kind which may involve sacrifice of a live goat or chicken and/or 'hot' drink (alcoholic liquor) for libation to appease the gods for trespass. When the offender is ignorant of the taboo on restricted fishing in a particular area the penalty is usually mild. This kind of fishing restriction has helped in managing the fisheries in some parts of Kolokuma/Opokuma and Yenagoa LGAs.

Consumer Preference

The survey data indicated that fish are preferably bought from the fish landing sites or the open market. This underscores the need for the establishment of fish markets in the State where people can go and buy fish. Besides, the people buy almost any species or kind of fish – be it live, fresh, frozen smoked or canned. From the survey, 80 percent of respondents stated that most accessible species of fish are the imported frozen fish (mackerel), canned sardines, tuna and mackerel, live or fresh local species of catfish, snakehead and tilapia. Ninety percent (90 percent) of respondents stated that they eat fish daily and spend over N4,000 (about US\$10) monthly for the purchase of fish for their families monthly. Thirty percent indicated interest in keeping ornamental fish or just any fish as pets in their homes, particularly the electric catfish, African catfish, tilapia and the exotic gold fish.

Water resources in Bayelsa State

Nigeria has a rich fisheries sector that consists of offshore waters between the 30 mile territorial limit and the 200 mile Exclusive Economic Zone (EEZ), a coastline of 853km of which Bayelsa State has the longest stretch of 200 km. The major rivers in Bayelsa State which empty into the Atlantic Ocean at different points forming different river mouths include Ramos River, Dodo River, Penington River, Digatoro Creek, Middleton River, Ikebiri Creek,

Fish Twon River, Sangana River, Nun River, Brass River, St Nicholas River, Santa Barbara River, and San Bartholomew River. There are several other rivers, rivulets, streams, ponds, lakes, and man-made burrow pits dotting the landscape of the State (NDWC, 1996). Some of the lakes are tied to key fishing festivals in the State.

Fishing Festivals

There are many fishing festivals that take place in different communities at different times of the year in the State. This is expected as fishing is the main occupation of the people of Bayelsa State. Some of these festivals include Lake Efi fishing festival in Sabagreia; Ogbugo fishing festival in Ogu; Seigbein fishing festival at Amassoma and Sagbama; and Opuaduno Lake fishing festival in Akeddeowei Opuaduno (see Table 1). Most of the festivals take place within the first five months of the year. This maybe so as it coincides with periods of relatively low rainfall, so as not to allow weather to hinder an otherwise joyous occasion. Reports from the survey indicate that most respondents (90 percent) subscribe to the fact that Government should be involved in the fishing festivals in the State as an avenue for interaction between Government and the fisher-folk and to boost tourism and showcase the rich culture of the Ijaw people to the world.

Table 1: Some of the fishing festivals in Bayelsa State

Festival	Location/LGA	Date of Festival
Lake Efi	Sabagreia, Kolokuma/Opokuma	Held periodically
Ogbugo	Ogu; Yenagoa	Held periodically
Seigbein	Sagbama Town, Sagbama	27 th May
Seigbein	Amassoma; Southern Ijaw	28 th – 30 th May
Opuaduno	Akeddeowei, Southern Ijaw	March annually
Boupere	Oporoma, Southern Ijaw	19 th – 25 th April
Akpiya	Sagbama Town, Sagbama	Every four years, held in April
Ologbo	Elebele, Ogbia	Every five years

Gender involvement in the fishery sector

a) **Inland Freshwater Fishery:** both fin and shellfish are exploited in inland water bodies in Bayelsa State. For ease of presentation, these have been grouped into shellfish fishery, comprising the freshwater clam and prawn fishery and the fin-fish fishery.

- i) **Freshwater Clam harvesting:** The activity of harvesting the freshwater clam is dominated by men ranging from 20 to 30 years of age (Ansa and Ansa, 2004). The clam is a bottom dweller and found at depths exceeding 4 meters. In some communities, men forbid their daughters and wives from fishing for the clam because of the risks involved in the harvesting process, which involves diving to the bottom of the river, gathering of the heavy shells and swimming up to the top without any form of breathing aids! (Ansa and Ansa, 2004). The survey data revealed that processing and marketing of the clam is mainly done by women.
- ii) **Freshwater prawns harvesting:** Survey data revealed that the fishing of freshwater prawns is solely carried out by women, across the six LGAs surveyed. This finding supports that of CEHRD (2007). However, a few men support their wives in operating the paddle-propelled dug-out canoe while she tends to her traps and harvests the prawns.
- iii) **Fin Fish capture:** The men dominate the fishery accounting for 78 percent of the activities in the freshwater areas and inland creeks.

b) **Processing:**

Processing of both shellfish and finfish is solely done by the women. Traditional smoking kilns (*altar*) are popular. The model is made of mud or in mud-huts with cane mats provided for placing the fish over the fire made from wood. Drums for smoking of fish are also popular.

c) **Marketing:**

Ninety-five percent of fish marketers are women.

d) **Markets and Fish Landing Sites:**

There is no market designated solely for fish sales in Bayelsa State. There are no specific landing sites for freshwater fish species; as most of the fisher-folk involved in this fishery are scattered across different freshwater bodies, fish both from culture and capture are transported to markets in and outside Bayelsa State for

sale. Markets within the state where fish are sold include Swali– Daily Market (Yenagoa LGA), Kaiama Market (Kolukuma/Opoluma LGA), Zarama – Friday Market (Yenagoa LGA), Akenfa– Monday Market (Yenagoa LGA), Igbogene - Thursday Market (Yenagoa LGA) and Tombia junction – Friday market (Yenagoa LGA). The high number of markets in Yenagoa LGA. is probably because it is the state capital and has a higher population than other LGAs, therefore there is an increased number of buyers who would purchase fish from these markets.

Proposed Strategic plan for the sustainable development of small-scale fisheries sector

To develop the fisheries sector as a means of improving the economic and social livelihoods of Bayelsans, and to eradicate hunger and enhance nutritional standards of the populace, activities geared towards the development of the sector would have to be carried out, during defined periods of time. Therefore, Table 2 provides suggested timeline and activities for the short, medium and long term goals for the inland small-scale fishery sector of Bayelsa State.

Table 2: Strategic plan for the sustainable development of small-scale fisheries sector in Bayelsa State

Goal	Period	Proposed Activities	Action by
Short Term	2022 – 2023	- Promote and develop small scale fisheries enterprises - Train entrepreneurs in the various businesses along the fisheries and aquaculture value chains. - Establish Fisheries Clubs in the Primary, Secondary and Tertiary institutions in the State. - Create awareness in our young ones of primary school age in the value of our fisheries resources and how to conserve them. - Government should promote fish eco-tourism as a means of generating revenue for Bayelsa people.	Legislators, Ministries of Trade & Investment; Agriculture and Natural Resources; Education; and the corresponding Federal Ministries, Small-scale fishers, Fish processors and marketers
Medium Term	2023 to 2028	- To develop sustainable techniques for the exploitation of untapped aquatic/fisheries resources - Conservation and sustainable development of inland freshwater fisheries through the harnessing of traditional ecological knowledge and creating of fish sanctuaries. - To standardize developed native technology and skills in fisheries e.g., harmonizing, family/community fishing festivals into state events; establishing factories for the production of indigenous fishing gear and vessels (canoes). - To introduce ornamental fish production and sport fishing in the State. - Government should enhance river fisheries by creating pollution free water bodies. - Establish centrally located fish preservation and processing factories (cold rooms, smoking kilns, and cannery); to prevent spoilage and for value addition.	Small-scale fishers, All research institutions, Community based associations, Non-State Actors, Legislators, Ministry of Environment, Ministry of Youth and Sports Development, Ministry of Agriculture and Natural Resources
Long Term	2028 to 2050	To make Bayelsa State a renowned fisheries destination or the fish basket of Africa; providing fish and fisheries products that compete favourably on the international market; thereby attracting foreign exchange earnings to the people of Bayelsa.	Small-scale fishers, Federal Ministries of Agriculture

		• Adopt management strategies for propagation and conservation of indigenous species of fish through breeding and stocking of open water bodies such as rivers, streams, and lakes. • Protect traditional fish sanctuaries and natural breeding grounds to prevent extinction of indigenous species of migratory fin and shellfish. • To establish standard fish markets in each local government area of the state for sale of different species of fish for local consumption.	and Rural Development Water Resources, Environment, Trade and Investment and their counterparts in the State, Legislators, Traditional rulers & Elders

Conclusion and Recommendation

Bayelsa State has a unique assemblage of freshwater fisheries resources which are being exploited actively across the state in the myriad of lakes, creeks, and rivers. Collaborations could help in further developing the small-scale fisheries sector in Bayelsa State. Stakeholders should partner with the State Government to increase fish production output and innovative use of the abundant water and fisheries resources in the State. Establishment of out-stations of NIOMR and NIFFR as well as College of Freshwater Fisheries Technology should be solicited for from the Federal Government through the Honourable Minister for Agriculture and Rural Development and the Executive Secretary of the Agriculture Research Council of Nigeria. Such partnerships will go a long way in bridging the gaps that exist in the State. The research institutions could also collaborate with the existing higher institutions in the State to strengthen research and training of students in fisheries, aquaculture, marine biology, and related courses. External assistance could also be brought into the State, like technical assistance from the Food and Agriculture Organisation (FAO), Rome, Italy. The consultancy services of the African Regional Aquaculture Centre (ARAC) situated in Port Harcourt should be explored for training, research and development of aquaculture in Bayelsa State as a sustainable means of complementing the much exploited fisheries resources in the inland water bodies in Bayelsa State.

References

- Ansa, E.J., Ansa, J.E.O. (2004). Aspects of the fishery of the freshwater bivalve *Galatea (=Egeria) radiata* in the Niger Delta. *African Journal of Interdisciplinary Studies*. Vol. 5 (1): 12 – 16.
- Binyotubo, T.E. (2019). A guide to fishing gear technology. Tony Endor Binyotubo publ. 74 p.
- CEHRD (2007). Small scale shrimp fisheries in Nigeria. Conservation and Environment Program Centre for Environment, Human Rights and Development (CEHRD). CEHRD Tech. Report 1. 64 p.
- FAO (1995). Code of Conduct for Responsible Fisheries Rome, 41 p.
- FAO (2002). Implementation of the International Plan of Action to prevent, deter and eliminate illegal, unreported and unregulated fishing. *FAO Technical Guidelines for Responsible Fisheries*. No.9. Rome, FAO. 122p.
- FAO (2005). Increasing the contribution of small-scale fisheries to poverty alleviation and food security. *FAO Technical Guidelines for Responsible Fisheries*. No. 10. Rome, FAO. 79 p.
- Idodo-Umeh, G. (2003). Freshwater Fishes of Nigeria. Taxonomy, Ecological Notes, Diet and Utilization, IdodoUmeh Publishers Ltd., 232 p.
- Kingdom, T., Emmanuel, A.O. and Oginnike, T. (2013). Fisheries development in Bayelsa State (1996 – 2012). Proceedings of the 27th Annual Conference and Biennial General Meeting of the Fisheries Society of Nigeria hosted by the Niger Delta University, Bayelsa State from 25th – 30th November, 2012. p428 – 430.
- NDWC (1996). Niger Delta Wetlands Centre. Report on Preliminary baseline survey of the flora and fauna of the lowland oil palm project area, Rivers State.
- Olaosebikan, B.D.; Raji, A. (2004). Field guide to Nigerian Freshwater Fishes. 2nd Edition. Federal College of Freshwater Fisheries Technology, New Bussa, Nigeria. 111p.

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Strategies for Promoting Women Participation in Fisheries and Aquaculture in Nigeria

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Abstract

Women are very pivotal to the development of agriculture in any nation. In fisheries and aquaculture enterprise, women have been reported to play some significant roles. However, a growing body of evidence suggests that addressing gender issues and integrating women's empowerment interventions into conservation result in improved governance and ecological results. The effectiveness of these approaches is improved when women's roles and perspectives in the sector are better understood. Studies have shown that women are mainly involved in hatchery and live food units. Women also play an important role in administration, fisheries research, education and training as reflected by the numbers of female graduates employed in such fields. The marketing of fish products for local markets was found to be predominantly carried out by women. Women are also temporarily and permanently involved in activities such as fish vaccination and the construction and manufacture of nets. Women play a key and vital role in the Fisheries value chain in Nigeria especially when we look at their involvement in the marine, artisanal and Aquaculture sub-sector of the Fisheries. Their participation in terms of number and output have been limited due to some constraints affecting their productivity. This paper therefore reviews their involvement in fisheries and aquaculture activities, constraints limiting their performance and strategies that will enhance their output in fisheries and aquaculture activities.

Keywords: Women, Fisheries, Aquaculture, Food security.

Introduction

Women are crucial to fisheries and aquaculture sector worldwide, fisheries and aquaculture production activities provide an estimated 155million people of whom a substantial proportion is female in developing countries as most fishing activities fall into the small scale fisheries sector employing roughly 37 million people and directly affecting the livelihood, poverty prevention and alleviation and food security of approximately 357 million others (Nwabueze, 2010). Various studies have been carried out on the roles of women in fishing activities as it made effort in revealing the strength of women in aquaculture agreeing with the fact that the world two major fish producing countries, China and India, women represent respectively 21% and 24% of all Fishers and fish farmers (FAO 2012). Women make up at least half of the inland fisheries workforce with 60% and 80% of seafood marketed by women in Asia and West Africa (FAO, 1999).

Sustainable fisheries are vital for achieving food security, alleviating poverty, and increasing economic growth around the world. In coastal countries, seafood accounts for up to 70% of protein intake and is an essential source of vitamins, fats, and minerals (UNDP, 2018). Women play a substantial role in the sector, making up nearly half of the overall fisheries sector workforce (Cochrane *et al.*, 2019). Women are present throughout the value chain, women are found in harvesting, processing, marketing, trading, and leadership roles. However, persistent gender inequalities prevent women from fully participating in economic opportunities and decision making, ultimately restricting the potential of the sector (Cliffe and Akinrotimi, 2015). Additionally, a limited understanding of women's unique roles and contributions can result in a lack of recognition of their needs and interests in policies and programs, therefore affecting sustainable development outcomes (Adebayo and Pitan, 2001). This paper therefore reviews the constraints and strategies for promoting women participation in fisheries and aquaculture.

Activities of Women in Fisheries and Aquaculture

Women in Nigerian Fisheries Sector

Nigerian women play very important role in the various Sector of Nigerian fisheries; they are engaged in wide range of activities (especially in processing and marketing)-like other women in fisheries all over the World; the Nigerian women in fisheries are no exception; they are the backbone of fresh and dry fish marketing from very early times by vending in rudimentary fish markets as well as carrying fish on head load sales, door to door. Fishing is often associated with the men who typically harvest fish from vessels offshore (Babale, 2003). However, in practice,

men's fishing activities are heavily supported by women who play essential roles in not only processing and sales but by also financially and logistically supporting fishing expeditions. A closer look at the sector therefore reveals that women and men working in fisheries typically fill distinct, but complementary roles (Alamu, 1998). When women's roles are unrecognized, their contributions are undervalued and the impacts of potential fisheries management decisions on fishing families and communities cannot be adequately understood.

Women in Harvesting

Harvesting is the process of catching or collecting fish, mollusks, crustaceans, and other species for consumption, trade, or sale. Women's and men's roles in harvesting activities are embedded in their social, cultural, and economic contexts. Traditionally, women are more involved in nearshore harvesting methods, such as collecting and gathering activities (Acharya, 2003).

Women in Fish Processing and Trade

In the fisheries sector, processing is a series of mechanical or chemical operations such as drying, salting, smoking, freezing, cutting, or packing fisheries products in order to change, preserve, or trade them. Women make up the majority of the world's industrial- and small-scale processors, holding up to 90% of these jobs. This makes many women's livelihoods directly reliant on a sustainable supply of quality fish. Depleted fisheries could downsize or close industrial processing plants, thereby negatively impacting women through lost wages and jobs. In small-scale fisheries, exhausted fisheries constitute the loss of entire livelihoods as women not only process goods, but also market and sell them (Adeleke, 2014).

Women in Aquaculture

The role of women in aquaculture, like their role in the rest of the economy, is shaped by the changing division of labor in society. With the unprecedented growth of aquaculture and the diminishing fish harvests of recent years, aquaculture appears to be a promising route to achieve food and nutritional security in developing countries (Olufayo, 2012). It now represents the fastest growing food sector in the agricultural industry (Olaoye *et al.*, 2012). Where women are employed in aquaculture they are predominantly involved in actual production than managerial roles. Women rarely hold senior management positions in the aquaculture sector and men have more promotion opportunities. Jobs in aquaculture are widely perceived as being dangerous and uncomfortable for women. As a result women have a low representation in the sector, are usually in jobs of lower importance and often on a temporary basis (Odulate *et al.*, 2011). In recent years, women participation in aquaculture activities have increased but not to the expected level.

Cooperative and Role of Women in Fisheries and Aquaculture Sector

Over the years the Nigerian women in the fisheries value-chain have been organized into fisheries cooperative society though we have a very few that do not belong to any union but operate individually with their operation. Being members of cooperative societies has enabled the women to upgrade their status (to an extent), as members are able to get government and private sector assistance in terms of loans (though often these funds are not enough); subsidized inputs, capacity building etc. Also, these cooperative societies are often used to protect the interest of the members as well as to facilitate equitable dealings with their fish suppliers (especially in the industrial and Aquaculture Sector); for often the members of the cooperative societies are able to argue and stick to a certain price regime with the supplier rather than the other way round (for example, if their leaders insist that no members should buy the fish at a price above a certain margin, you can be sure none of their members will) – this in essence shows their power as being part of a cooperative society.

Commission agents/Brokers

Nwabueze (2010), Stated that, Commission agents play prominent role in the value addition chain analysis of fish especially the processed form. They also play a vital role in the bulking of fresh fish for regional marketing. Commission agents in the marketing of different forms of fresh water fish (like other commission agents) do not take title to the product but rather act on behalf of other traders along the marketing channels. They form the link between many intermediaries in the marketing channels. Among the roles played by this agents include provision of market information (price and demand) to women processors. Women processors rely on price information from commission agents to either sale or preserve their processed fish until the following market day. In return to services rendered, the agents receive commission. Women processors reported that they pay twenty naira to the agents for sale of small basin of processed fish. Commission agents compete for more customers (Processors, Wholesalers and so on) just as traders compete for prices.

Constraints Limiting Women Performance in Fisheries and Aquaculture

The constraints faced by women in fisheries and aquaculture are numerous, these include the following:

Omission of Women from Planning, Implementing and Monitoring Of Conservation Initiative

The varying threats of women in aquaculture include omission of women from planning, implementing and monitoring of conservation initiative in accordance with cultural norms where the cultural norms may appear prohibitive and adaptive to the support of women engagement in natural resource management (Njim *et al.*, 2004). Women are disproportionately represented in the unpaid labour force. Several cultural forces have been used in the past to keep women away from the fishing trade (Gopal *et al.*, 2014). In some communities like the Luo community in Kenya there is a law prohibiting menstruating women from going to the lake as they would contaminate the lake and affect its productivity. However the important role played by women in aquaculture have been to some extent derailed by the land tenure system which gives ownership right to males, inaccessibility to credit and saving services and facilities, high level of illiteracy and inadequate technical knowledge on pond management (KMFRI, 2017).

Low Capital and Technology Input

The women's activities in the role of fisheries and aquaculture are characterized by low capital and technology input. Most of their fish handling operations are without appropriate capacity to meet national and international sanitary and technical standards and hence possess low substantial benefit in fish trade. Women's work in fish value chain has not been optimized or linked to value chain finance in Nigeria –thus they are limited to various financial services being put up by the commercial banks for the Agricultural Sector in the country. This lack of Cooperate finance has in essence debar the women from upgrading their fisheries activities and businesses in the various steps along the fisheries value chain, they have therefore not been able to build sustainable and viable fish trade especially when it comes to the export of fish and other fishery products (Ibrahim *et al.*, 2011).

Low participation in decision making due to gender inequality:

In most patrilineal societies like Nigeria, women are only to be seen and not heard, they are therefore not usually consulted before taking decisions. Because of gender inequality in some communities in Nigeria, the efforts of women in fisheries are not recognized, no matter how hard they try because they are regarded as minorities. There is therefore a need for attitudinal changes (UNDP, 1998).

Lack of basic education

This apathy towards women as equal partners in progress also contributed to the higher illiteracy level among female fisher folks. The age-old belief that women are weaker and meant only for procreation and culinary function should stop in the new millennium (Williams, 2006).

Lack of land ownership

Nigeria being a patrilineal society unlike Ghana and Rwanda, rural women are often disadvantaged in terms of land accessibility. Only in very few States can women own land. The land tenure system does not favour women. Changing the land tenure system could greatly affect the status of women, thus making them to go into fish farming (Williams, 2006).

Dearth of social and infrastructural facilities

Presence of infrastructural facilities like power, municipal water, good roads, health centres in the rural fishing communities could stimulate rural income; reduce fishing efforts and subsequently sustainability and development.

Restricted access to credit

This is a major handicap to effective participation of women in fisheries. Generally fisheries is considered a 'no go area' by most formal agric lending institutions in Nigeria as confirmed by many workers. The low literacy level of women has always been a constraint to accessing funds from formalized sources. They have to depend on credit from friends and thrift to purchase fish inputs such as nets, boats, fertilizers, feeds etc at subsidized rates. Cooperative society formation was recommended to facilitate better access to inputs. The bureaucratic bottlenecks like collateral securities have further aggravated the situation, hence the need to train the women. Past workers have confirmed women as being better managers of funds than their male counterparts Women repay loans faster than their male counterparts (most of whom divert loans to ostentatious transactions (Williams, 2006).

Inadequate Dissemination of Information through Extension Services/Change Agents

Because of the usually bad terrain in the fishing communities, there is generally poor access to extensionists/change agents. The creeks are not accessible to most transportation means.

Gender Based Violence

Though fisheries are an important entry point and opportunity towards advancing gender equality and increasing effective sustainable fisheries management, the sector is still challenged by pervasive inequalities, including GBV. Fisheries programming tends to not include considerations towards the elimination and prevention of GBV, constituting a lost opportunity and potential risk as programming can unintentionally exacerbate vulnerabilities (Aquilar, 2002). Worldwide, 35% of women have experienced some type of GBV in their lifetime.¹⁹ In the fisheries sector, structural inequalities and harmful social norms put women and girls in vulnerable situations, where they may be affected by and exposed to violence and abuse. GBV negatively affects the long-term health, well-being, and productive capacity of survivors, creating consequences that extend beyond the survivor to her family and community (UNDP, 2018).

Strategies That Will Enhance Women Participation In Fisheries And Aquaculture

A growing body of evidence suggests that addressing gender issues and integrating women's empowerment interventions into conservation result in improved governance and ecological results (Wara et al., 2007). The effectiveness of programmatic approaches is improved when women's roles and perspectives in the sector are better understood. For example, has improved the enforcement of regulations of near shore ecosystems (FAO,2018). Additionally, increasing women's access to improved processing technologies has reduced product loss and increased product value, allowing fishing families to realize the same income while catching fewer fish (FARM AFRICA, 2016). Evidence shows that interventions to improve women's entrepreneurial and negotiating skills have strengthened women's livelihoods through increased income and agency, as well as better social and health outcomes. The following have been highlighted as some of the strategies that will enhance women performance in aquaculture.

1. Women should be encouraged through introduction of specially designed programmes.
2. Fishing inputs should be made available to all irrespective of sex.
3. They should be encouraged to form cooperative association that would facilitate cheaper and better access to credit and inputs at concessionary rates.
4. Policy makers should adopt the 'Bottom-Up approach' which is tailored at the needs of rural women/fisher folks.
5. They should be consulted during policy formulation because they are the stake holders. There is a need for gender-sensitiveness in Nigeria's move to sustainable fisheries development.
6. The government should create a conducive enabling environment such as provision of social amenities in the fishing communities. Despite their being the major contributor to the domestic fish output, the coastal communities lack basic infrastructural facilities like power, post- harvest storage structures, health centres, municipal waters etc.
7. Enhancement of women access to factors of production such land, inputs and capital
8. Continuous monitoring of women to help them use the already existing resources and opportunities sustainably through improved technologies and innovations, credit extensions etc.
9. Women should be advised on what they need to do to meet the threshold required for access to financing mechanisms at regional and national levels.
10. Women intending to invest in aquaculture should be facilitated to visit well established farms to learn and get exposed to good farming practices

Conclusion

In conclusion, women are major contributors in agriculture and her work ranges from crop production, livestock production to fishing activities. From household and family maintenance activities to small scale trades. Despite such a huge involvement, her role and dignity has not been well recognized. Women's status is very low by all social, economic and political indicators ,thus, there is need to involve women in fish production in Nigeria if food poverty especially animal protein in quantity and quality is to be arrested.It is high time women are considered as equal partners in sustainable fisheries development in Nigeria. Women should never be seen as invincible but should be recognized as partners in progress towards sustainable fisheries development. They should be more involved in direct production especially in the area of culture fisheries which is more environment-friendly and less risky than capture fisheries.

References

- Acharya, M. (2003). Efforts at Promotion of Women in Nepal Kathmandu, Tanker Prasad Acharya foundation.
- Adebayo O, & Pitan O.O (2001). Role of women in marketing of frozen fish in Lagos state. Annual Conference of Fisheries Society of Nigeria Proceedings, pp. 435-437.22.
- Adeleke ML (2014). Adaptation of the artisanal Fisher folks to Climate change in the coastal region of Ondo State. Department of Agricultural Economics, Federal University of Technology, Akure, Nigeria, p. 1-44.11.
- Alamu, S.O (1998). Women in artisanal fish production: Kainji and Jebba Lake Basin. NIFFRI Annual Report, New Bussa, Nigeria, pp. 46-61.24.
- Aquilar, L (2002). Fisheries and aquaculture in coastal areas. Gender makes the difference. IUCN Briefing Notes, Geneva.
- Babale, U.G (2003). Role and Contributions of the Nigerian Agricultural Cooperative and Rural Development Bank Ltd to the development of the Fisheries Industry in Nigeria. Proceedings of Annual Conference of Fisheries Society of Nigeria, pp. 80-82.25.
- Cliffe PT, Akinrotimi OA (2015) The Role of Women in Fisheries activities in Some Coastal communities of Rivers State. *International Journal of Agricultural Research*, 10: 24-32.
- Cochrane, K. De Young, C. Soto, D. and Bahri T. (2009), Climate Change implications for fisheries and aquaculture: Overview of current scientific knowledge. FAO Fisheries and Aquaculture Technical Paper No. 530 Rome, FAO. 2009. 212pp
- FAO (1999). Guidelines for the routine collection of capture fishery data (FAO/DANIDA. Expert consultation, 18-30 May 1998, Bangkok, Thailand, FAO Fisheries Technical Paper. No. 382. Rome, PAO, 1999 113pp.
- FAO (2012) Strategies for Sustainable Animal Agriculture in Developing countries. Proceedings of the FAO Expert Consultation, Animal Production and Health Paper 107. 26.
- FAO (2018). The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable developmentgoals..Aquaculture (Vol. 35).
- FARM AFRICA (2016) Gender Impact Study of the Kenya Market-Led Aquaculture Program. <https://www.farmafrica.org/downloads/resources/farm-africas-kmap-gender-impact-study.pdf>
- Gopal N, Williams M J, Porter M, Kusakabe K and Sze Choo P (2014). Gender in Aquaculture and Fisheries. Asian Fisheries Science, (27S), 1–265. Retrieved from <http://s3.amazonaws.com/academia.edu.documents/36931880/2014-12-22-01>
- Ibrahim, H.I, Kigbu, A.A and Mohammed, R (2011). Women experience in small scale fish processing in lake Feferuwa fishing community, Nasarawa State, Nigeria. *Livestock Research For Rural Development* 23(3):1-8
- KMFRI (2017). Kenya's Aquaculture Brief 2017 Status, Trends, Challenges and Future Outlook. African Journal of Food, Agriculture, Nutrition and Development. https://www.kmfri.co.ke/images/pdf/Kenya_Aquaculture_Brief_2017.pdf
- Musa S, Aura C, Owiti G and Nyonje B 2012 Fish farming enterprise productivity program (FFEPP) as an impetus to *Oreochromis niloticus* (L.) farming in Western Kenya: Lessons to learn. *African Journal of Agricultural Research*, 7(8), 1324–1330. <https://doi.org/10.5897/AJAR11.1606>
- Njiru J, van der Knaap M, Kundu, R and Nyamweya C. (2018). Lake Victoria fisheries: Outlook and management. *Lakes and Reservoirs: Research and Management*, 23(2), 152–162. <https://doi.org/10.1111/lre.12220>
- Nwabeze, G.O, Ifejika, P.I, Tafida, A.A and Ayanda, J.O, Eric A.P and Behonwo, N.E (2013). Gender and Fisheries of Lake Kainji, Nigeria. A review *Journal of Fisheries and Aquatic Science* 8(1):9-13.
- Nwabueze AA (2010) The role of women in sustainable aquacultural development in Delta state. *Journal of Sustainable Development in Africa*, 12(5): 23-25.
- Nyandat B, and Owiti G. O. (2013). Aquaculture Needs Assessment Mission Report: Kenya. Retrieved from <http://www.fao.org/3/a-az041e.pdf>
- Odulate, D.O, George, F.A.O and Idowu, A.A (2011) Role of women in fisheries in Coastal wet land areas of Ogun State Southwest Nigerian Proceedings of Environmental Management Conference, Federal University of Agriculture, Abeokuta Ogun State Nigeria.
- Olaoye O.J, George FOA, Abdul WO, Adelaja OA, & Ashley-Dejo SS, (2012). Profitability and viability of fish farming enterprises using Government credit Agency Loan in Ogun State, Nigeria. *Nigerian Journal of Fisheries*, 9(1): 460-463.19.
- Olufayo, M.O (2012). The gender roles of women in aquaculture and food security in Nigeria IIFET 2012, Tanzania proceedings 7pp.

- Orina P, Ogello E, Kembenya E, Githukia C, Musa S, Ombwa V, Mziri V, Abwao J, Ondiba R and Okechi J (2019). Kenya marine and fisheries research cage culture in lake victoria , Kenya brief. <http://hdl.handle.net/123456789/1107>
- United Nations Development Program (UNDP) (1998) Baseline Survey of Agriculture, Rural Development, Health and Mass Literacy of States of Nigeria. conducted by Gothards-IHLS Consortium, Nigeria, pp. 1-23.20.
- United Nations Development Programme (2018). Leveraging the Blue Economy for Inclusive and Sustainable Growth. *Strategic Policy Advisory Unit*, (6), 1–7. <https://doi.org/10.1177/0022146514547328>
- Wara A, Nwabeze GO, Tafida AA, Abubakar SM (2007) Women in Fisheries: A case study of the Kainji Lake Basin, Nigeria. *Proceedings of the Fisheries Society of Nigeria*, p. 66- 67.21.
- Williams, S.B (2006). The Socio-economic potentials of women in Riverine small scale fisheries in Nigeria. Department of Agricultural Economics, Obafemi Awulowo University. Ile- Ife, Osun State, Nigeria.
- World Fish Center (2011) *Aquaculture , Fisheries , Poverty and Food Security* (No. 2011–65). Penang Malaysia. <http://pubs.iclarm.net/resource>

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Prospects and Challenges of Fisheries Based Tourism in Nigeria**Nwachukwu, I.C¹., Ani, N.A²., Akinrotimi, O.A³ and Onwujiariri, C.A⁴**¹National Institute for Hospitality and Tourism, Utako, Abuja, Nigeria^{2,3}African Regional Aquaculture Centre of Nigerian Institute for Oceanography and Marine Research, P.M.B. 5122, Port Harcourt, Rivers State, Nigeria**Abstract**

Nigeria is a country endowed with a lot aquatic and fisheries resources. These resources can be found in different parts of the country. Tourism has been described as an important economic venture that will take employment into the rural areas with the aim of alleviating poverty. This paper reviews the potentials, prospects and challenges of fisheries based tourism in Nigeria. The potentials of fisheries based tourism in generating employment for the rural dwellers. The means by which such a goal can be achieved is the main focus of this paper. It examines the concept of tourism and related subjects such as recreation, transportation and provision of lodging facilities. The place of tourism in employment generation together with a succinct outline of tourism institutional evolution is highlighted in the Nigerian context. Various tourism's benefits and prospects, which can be found in fisheries based tourism are discussed while constraints towards the development of tourism as it relates to economic empowerment were mentioned. Constraints which include lack of cultural acceptance of fishery-based tourism as a source of livelihood; inadequate infrastructure for development for fishery-based tourism facilities; inept promotional activity and lack of tourism awareness among the local people; dependence on private sector action and lack of monetary support for the project; environmental pollution and unplanned development, particularly in coastal areas; lack of security and safety provisions, for local and especially for foreign tourists; lack of legislation, regulation, standards, guidelines, and safety codes and poor coordination and integration of the activities of different agencies (Government and non-governmental, fishers, scientists, tour operators, and other Fisheries based tourism stakeholders. This paper rounds off with suggestions and possible solutions towards improving fisheries based tourism development in Nigeria.

Keywords: Fisheries, Aquatic resources, Tourism, Nigeria.

Introduction

Tourism is a leisure activity involving the movement of people to destinations away from their usual residences. It is often international in character. According to the definition of the Association of International Scientific Experts in Tourism (AISET), tourism is the sum total of the phenomenon and relationships arising from the travel and stay of non-residents in so far as this does not lead to permanent residency and is not concerned with any earning activity (Aylward *et al.*, 1996). Fisheries based tourism is branch of ecotourism that focuses on the enhancement of fisheries and aquatic resources through tourism (Carey *et al.*, 2012). However, The International Ecotourism Society (TIES), defines fisheries based tourism as “responsible travel to aquatic environment that preserve the surroundings, maintain the well-being of the local people and involves interpretation and education (UNEP-MAP, 2009). Fisheries based tourism thus involves environmental friendly support for local livelihood diversification and nature conservation sustainably for riverine and coastal communities (Brandon, 1996). It can also contribute to increasing sustainable productivity, infrastructure development in remote areas and boosting the employment rate in rural areas.

Apart from being an important protein source and supporting vital ecosystem functions, fishing also has the potentials of providing recreational benefits (Kalpana, 2012). Many tourists are losing interest in the traditional sun, sand and sea packages and are instead looking to experience something more actively engaging. For some, fishing activities and exploring cultures with an ancient fishing heritage can be significant attractions (Diffey, 2012). Thus Fisheries-Based Ecotourism has received increasing attention in recent years. This can involve a wide range of activities, including recreational spin-cast fishing, excursions in professional fishing vessels, learning from locals about alternative fishing methods and fishing gear, game fishing and discovering exotic marine environments and their biodiversity (FAO, 2012). While there is no universal definition for fishing tourism, recreational fishing ranks as one of the most popular leisure activities in the world today. It is both an integral part of modern culture and an important sector within the global tourism industry (Krugger, 2005). This paper therefore reviews the potential of fisheries based tourism as an aspect of ecotourism.

Potentials of Fisheries Based Tourism in Nigeria

Artisanal fisheries ecotourism can offer various activities for tourists for the benefit of both the fishers and local communities. Founding appropriate ecotourism development strategies and implementing activities will prove to provide additional sources of income to the families and region of the people (Ipinmoroti *et al.* 2007). The fisheries sector has been growing very rapidly with 120 million people estimated to be partly or totally dependent on fisheries related activities of which 95% are in developing countries (Food and Agriculture Organisation (FAO), 2005). This rapid growth has led to fears of a world-wide fisheries crisis (Goodwin, 1998), and tropical fisheries are no exception (Young, 1999). Though fisheries ecotourism is still in its emerging phases, it is estimated that up to 700 million people might be engaged in some form of recreational fishing creating several million jobs and contributing to the national economy of countries (Diffey, 2012). Other activities related to fisheries ecotourism have been established depending on the natural assets of the site and its cultural and social heritage (Diffey, 2012). The main aim is to support local communities by making ecosystem conservation and management of natural resources a source of economic benefits, for the present time and in the long term run (Dellink & Ruijs, 2008).

Aspects Fisheries Based Ecotourism

1.Dam and Reservoir

Wildlife, including fisheries, is a valuable resource in many other regions of Africa. The building of new large reservoirs often increases the tourist potential, for example, fishing for tiger fish below the spectacular Kainji dam in Nigeria is a real attraction since success can be almost guaranteed in these waters because the fish which have been used to travel upstream are now prevented from doing so by the dam and congregate below it.

2.Sport Fishing

In Nigeria, Tarpon fish can be found in the coastal parts of Ondo and Rivers State, (Anyanwu and Kusennju, 2006. 2007). Tarpon could be cultured in brackish water, freshwater and marine environment and grow fast when stocked with Tilapia as prey (Anyanwu, 2004). The large scales are used in ornamental work and in preparation of artificial pearls. These attributes make Tarpon a good candidate for the establishment of aquatic parks for ecotourism because it can easily be sighted in the water and would generate revenue for a long period of time. Also, Mention should be made of the annual fishing festival at Argungu (Sokoto River, Nigeria) as an example of an important sport fishing event entirely national in its significance but with important tourist attraction potential. Nigerians from many parts of the country come to Argungu drawn by prizes and the social aspects; consequently it has a major impact on developing tourist facilities.

3 Fishing Tournaments

In different fishing community, Fishing tournaments can be organized involving fishers having fishing experience of 10 years and above to catch the largest quantity of a selected fish species using a defined legal fishing gears within a given time.

4.Rowing Tournaments

Rowing competition using fishing boats can be held by classifying different boat sizes with a fixed number of rowers per boat for a predetermined distance.

5. Diving Competition

Diving competition could be organised amongst fishers at different categories based on age range to see the highest harvester within a given time frame.

6.Art Competition

Art competition involving youths of different age range could be organised using shells of shellfishes. This will reduce youth restiveness.

Benefits of Fisheries Based Tourism in Nigeria

Fisheries based tourism involves four sectors' the tourists, the host communities, the environment and the tourism Industry. 'Tourism highlights the need for proper management of the environment and through effective policies and planning; it can ensure that the environment of an area is preserved. It is also a catalyst for residential development. Fisheries based tourism can stimulate the establishment of a new and improved transport services to and within a regional area. Ecotourism provides economic incentives and promotes conservation of wild lands, generates income

lor park management and brings needed income to rural populations. It promotes conservation, has low negative visitor impact and provides for beneficially active socioeconomic involvement of local populations (Adebajo, 2002). Odunlami (2003) reported that the Argungu Fishing Festival is an attraction spot for many tourists now and Kebbi State government is poised to develop it to a world class event.

Globally, tourism benefit in two main ways – trade and redistribution. Tourism stimulates international trade as some tourist's needs may have to be imported from often nations e.g. planes, hotel and hostel facilities, foods and drinks (Roness, 2011). Also most international tourists move from high income countries and spend their discretionary income in low income countries. Tourism therefore, makes a significant contribution to a nation's Gross National Product (GNP) since international visitors are a valuable source of foreign currency (Wells, 1997). This is realized by the sale of services and related goods. Kenya is an example of a developing country where significant percentage of gross receipts (as high as 90 percent in 1989) comes from tourism (Kasali, 2002).

Tourism is a major source of income and foreign exchange earner for countries whose potentials have been adequately developed. Tourism is a larger concept than recreation. People recreate or go on tour for reasons ranging from the need to escape from boredom of locality and job to the desire to have fun and relax while some persons do it to meaningfully utilize their spare time or for the intrinsic value of tourism and recreation (Godwin, 1998). Benefits, which accrue from tourism, include direct satisfaction to individuals, enhancement of the overall and physical quality of individuals thereby adding to the productivity of the individual and society, important third-party benefits such as increased business and property value and the generation of wealth and employment (Berkes *et al.*, 2001).

Constraints Confronting Fisheries Based Tourism in Nigeria

In the coastal area of Nigeria, despite the immense potential of Fisheries based Tourism, there exist several problems militating against the prospects of this industry in Nigeria:

- Lack of cultural acceptance of fishery-based tourism as a source of livelihood
- Inadequate infrastructure for development for fishery-based tourism facilities
- Inept promotional activity and lack of tourism awareness among the local people
- Dependence on private sector action and lack of monetary support for the project
- Environmental pollution and unplanned development, particularly in coastal areas
- Lack of Security and safety provisions, for local and especially for foreign tourists
- Lack of legislation, regulation, standards, guidelines, and safety codes
- Poor Coordination and integration of the activities of different agencies (Government and non-governmental, fishers, scientists, tour operators, and other Fisheries based tourism stakeholders).

Possible Solutions

1. There should be integration between fisheries and tourism which can expand the potential of providing jobs for local communities, especially fishery workers can become more involved in the tourism sector.
2. River cruises should be chosen as a major tourist attraction, giving a boost to the tourism industry. There are hundreds of angling locations around the country yet to be explored and to be put into focus for attracting tourists. Initiatives should be carried out to explore the unfamiliar places.
4. The people in the river and coastal areas should be friendly in behaviour and must believe in hospitality, they would likely utilize an opportunity to increase their family income and accept a role in tourism development.
5. The fishers should be willing to show their various activities such as fish landing, and fish processing activities, these can form part of travel package.
6. By using their specific skills, equipment and resources, small-scale fishers in the coastal areas should be willing to offer services to tourists (e.g., act as guides along the coast or take people on their boats to watch wildlife). These activities may also be a source of extra income, as a tourist may be willing to pay for the opportunity to attend fishers at work. Some fishers may even be able to offer accommodation in traditional fishing cottages as an added activity. Beyond this, tourists can consume locally produced fish, if there are restaurants or fish shops where they are available, thus creating other opportunities for fishers to market their catch
7. Seafood in different delicacies should be made available. For tourists, seafood is an essential local culinary attraction. There is a high demand for local seafood among tourists visiting the coastal area as well as among residents. Furthermore, restaurants try to buy fresh and local seafood as much as possible.

8. Local entrepreneurs and infrastructure developers may explore avenues to invest in building hotels, resorts, and recreational centres near coastal areas. Also, the financial institutions should relax their existing money lending policies to encourage borrowers to receive a bank loan to set up new infrastructures.
9. Various groups of NGOs should take the lead to conduct empowerment activities on tourism matters at the local level, as this can help in tourism promotion. Local influence groups such as regional political parties, cultural organizations, and civil societies may introduce advocacy activities at the policy level to expand the sort of tourism intended to benefit the poor, working to achieve poverty reduction, conservation of natural resources and promotion of traditional cultures, and building peace and stability in these coastal communities.
10. The Tourist Sites should be made more easily accessible by introducing a public road or water transportation system. Also, Nigerian Government needs to develop more basic services such as hotels, resorts and guest houses. Promotion of these services should be done in cooperation between the private sector and the government tourism organization. Moreover Tourism professionals need to build personal relationships with community leaders, to progressively involve them in providing various services and forms of hospitality to tourists. Such relationships can be initiated, for instance, by organizing joint working groups or promotional events.
11. Security should be made available by the government to protect the tourists from kidnapping, which are prevalent in these areas.

Conclusions

There is unanimity in considering fishing tourism as a tourism modality with great potential, due to the benefits it can bring to communities in which small-scale fishing plays a significant role in the economy. Benefits related to the revitalisation of the fishing sector, and also to the promotion of fishing cultural heritage, so fishermen can continue to exploit their knowledge and professional skills, and maintain the social networks linked to fishing. There should be a developmental plan this plan should include recognition of existing systemic problems and identify strategic plans to solve problems with minimal effort and costs, which will guide the system in a desirable direction. Fisheries based tourism systems must be formed, led and operated by residents in order to help the local community claim its share of the profits from this venture. This must be complemented by the development of cooperative governance that guarantees an appropriate level of support from the central government, local government and specialist groups, in order to enhance local capacity.

References

- Adebajo, A.A. (2002): Tourism Revitalization and Development as Employment Generating Investment in The Rural Areas of Ondo State. Term Paper on Tourism and Recreation Planning. Department of Urban And Regional Planning. Federal University of Technology, Akure.
- Amodu, E. I. (2005). An Investigation of Tourist Potentials for Socio-Economic Development in Ondo State of Nigeria. Unpublished Postgraduate Diploma Thesis. Department of Urban And Regional Planning, Federal University of Technology, Akure.
- Aylward B, Allen K, Echavarria J, Tosi J (1996) Sustainable ecotourism in Costa Rica: the Monteverde Cloud Forest Preserve. *Biodiversity and Conservation* 5, 315-343.
- Berkes, F., R. Mahon, P.A. Mcconney, R.B. Pollnac and R.S. Pomeroy, (2001) Managing Small-scale Fisheries; Alternative Directions and Methods International Development Research Centre, Ottawa, Canada..
- Brandon, K (1996) Ecotourism and conservation: A review of key issues. In: Environment Department Papers No 033. Biodiversity Series. .World Bank, Washington, DC, USA.
- Carey, J., Falk, J., Havens, K. (2012). Sustainable Coastal Tourism Renewing Sea Grant's Role. National Oceanic and Atmospheric Administration. P. 76.
- Dellink, R. & Ruijs, A. (2008) Economics of Poverty, Environment and Natural- Resource Use. Springer. p 87- 100.
- Diffey, S., (2012) Artisanal Fisheries Income Diversification Study Eco-Tourism & Recreational Fisheries, Smart Fish Programme Report SF/2012/17.
- FAO (2012) Small-scale and artisanal fisheries: Key features of small-scale and artisanal fishing, Fisheries and Aquaculture Department. Food and Agriculture Organization of the United Nations.
- Fasoranti, A.O. (2002). Employment Generation Using Tourism Development. *Term Paper on Tourism and Recreation Planning*. Department of Urban and Regional Planning. Federal University of Technology, Akure.
- Goodwin H (1998) Sustainable tourism and poverty elimination. A discussion paper for DFID/DETR Workshop on Sustainable Tourism and Poverty.

- Ipinmoroti, M. O.; Taiwo, I. O. & Olopade, O. A. (2007). Attitude of Fisherfolks towards Fisheries Recreationists. *Journal of Sports Psychology Association of Nigeria* 3; 65 – 72.
- Kalpana, A. (2012) Environmental Sustainability of Ecotourism. *Research Journal of Economics and Business Studies*. Vol. 01, Nb. 09.
- Kasali, M. A. (2002). Employment Provision Potential Of Tourism Resources In Ondo State Rural Communities. Term Paper on Tourism and Recreation Planning. Department of Urban and Regional Planning. Federal University of Technology, Akure.
- Kruger O. (2005) The role of ecotourism in conservation: panacea or Pandora's box? *Biodiversity and Conservation* 14, 579-600.
- Nader, M.R; M. A. Dagher and S Indary (2013) Ecotourism potential in the artisanal fisheries sector along the Lebanese Coast. UNDP report.
- Oyinloye, M.A. (2003). Socio-Economic Effects of Recreational Facilities on the Community; A Case Study of Two Centres in Akure, Nigeria. *Challenges of Environmental Sustainability in a Democratic Government*. National Conference of The Environment and Behaviour Association of Nigerian (EBAN). Akure, Ondo State, Nigeria. Pp 347-355.
- Rettig, R. B. (2005). Practices and Problems with Licensing Limitations in the USA and Canada. Retrieved from <http://www.fao.org/docrep/005/ac750E.htm>. on May 29, 2007. 6.
- Roness, L. A.(2011) Inventory of Fishery-Related Tourism Initiatives and toolkit. Dartmoth: Atlantic Policy Congress
- UNEP-MAP (2009) Sustainable Coastal Tourism, an integrated planning and management approach. p. 87. ISBN: 978-92-807-2966-5.
- Wells, M.P (1997) Economic perspectives on nature tourism, cibervation and development. In: Environment department papers, no. 55. Environmental economics series. World Bank, Washington, DC, USA.
- Young, E. (1999) Balancing Conservation with Development in Small-Scale Fisheries: Is Ecotourism an Empty Promise?. *Human Ecology*, 27 (4):112-120.

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Roles and Approaches of Extension Agents in Aquaculture Development in Nigeria

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Abstract

Aquaculture is the fastest growing food-producing sector in the world. It provides a significant supplement and substitutes to wild aquatic organisms and creates employment, generates income and provides opportunities for human development. This paper reviews the roles and different approaches of extension agents as a catalyst for development in aquaculture. Agricultural extension systems have been formulated and developed for people living in rural and urban areas to deal with farm production and marketing activities which have been the main livelihoods of these people. Agricultural Extension is defined as the use of communication methods in a planned manner to help farmers make ideas and right decisions in every subject they need. However, people engaged in fish farming need help in production techniques, input use, marketing, and other activities regarding rural society. For this reason, agricultural extension agents, also called change agents, participate in the extension process to determine the problems of fish farmers by the most consistent and positive manner. Moreover, these agents provide a two-way link between research institutions and farmers and cooperate with rural development organizations. The overall purpose of this work is to review the roles, different approaches, and tools utilized by extension agents involved in aquaculture operations.

Keywords: Aquaculture, Extension Agents, Rural Development, Roles, Approaches

Introduction

Agricultural extension can be defined as an ongoing process of getting useful information to farmers and assisting them to acquire the knowledge, skills and attitudes to use effectively the information and technology to increase productivity (Chambers *et al.*, 2013). The effectiveness of extension services is also highly dependent on the ability of extension agents who are qualified, knowing their roles and competent as the whole extension process is dependent on them to transfer information to farmers. Extension services world-wide are organized on different principles. In some countries extension programs serve to transmit national directives to rural areas. Rural areas are perceived to be highly traditional, resistant to change, and unaware of technological advances (FAO, 2008). Many extension approaches and strategies rely on technology transfer with top-down development without having a framework for feedback from farmers (John *et al.*, 2014). However, Dillon (2012) believed that "any viable fisheries program must be built from the top down". In more recent years the shift has been towards greater farmer participation, although it is difficult, especially with a new technology, to have the patience to elicit farmer response. It is far too easy to assume the farmer does not understand.

Present Level of Fish Production in Nigeria

In Nigeria, fish alone contributes on the average 20 – 25% per caput animal intake and could be as high as 80% in coastal and riverine communities (FAO, 2000). Tobor (1992) and Ajana (2002) reported that the average annual demand for fish in Nigeria between 1995 and 2000 was estimated at 1.22 million metric tonnes and that this might increase to about 1.425 million metric tonnes by the year 2005. Adamu (2007) however, gave the actual total domestic fish production in 2005 as 579,500 tonnes, while production from aquaculture was 56,300 tonnes in the same year. Fasasi (2003) put the demand – supply gap of fish in Nigeria as 1.0 million metric tonnes while fingerlings demand – supply gap is over 500 million. According to Satia (1990), Artisanal fisheries contribute about 491 million tonnes, Aquaculture, about 57 million tonnes, Industrial (Trawler), about 33 million tonnes and Distance fishing (Imports) about 612 million tonnes. From the above analysis, less than 50% of the total annual fish consumed by Nigerians are produced locally. There is, therefore, the need not only to maximize the exploitation of our fishery resources but to concentrate more on the development of aquaculture which has the greatest potential to increase fish production for local consumption and export.

Roles of Extension Agents in Aquacultural Activities

Role can be described as a major area of functioning which encompasses any number of competencies and outputs that a person can perform. In most of the time, most people can perform more than one role in their daily lives. Conversely, Anastasio *et al.* (2010) he describes a role as part played by people in reach their objectives by working competently and flexibility within the contact of the organization's objectives, structure and processes. The role of extension officers' in the development of agriculture throughout the world is not in doubt. It has remained one of the prime movers in the development of agriculture sector. Hence, change agents refer to someone who deliberately tries to bring about a change or innovation (FAO, 2010).

1. Information Dissemination

Agricultural extension plays a significant role in community development. Its role in testing and disseminating research-based agricultural knowledge and technology to rural people results in improvements in the aquacultural sector (Akpabio *et al.*, 2016). According to Anderson (2007), extension has facilitated the dissemination of information about new and improved species of fish and associated management practices leading to the improved socio-economic status of the rural communities. This is because farmers need information regarding the best technological application for aquacultural productivity as well as post-harvest information that includes fish handling, processing, and marketing (Anaeto *et al.*, 2012). Furthermore, they need suitable and scientifically proven information concerning certain challenges like processing and market opportunities, pest/disease management to overcome these challenges working against good farming techniques as well as proper information on the influence of a changing climate (Birner *et al.*, 2008).

2. Identification of Farmers Needs

The effectiveness of extension service delivery largely depends on whether the needs of the beneficiaries, the farmers in this case are met. Therefore, identifying farmer needs becomes a crucial step in the success of rural extension programs. According to Hamisu *et al.* (2017), information required by farmers varies depending on the groups of farmers and as such, it may be designed to target a particular category. Moreover, diverse farmers possess different information search behavior based on reasons including education level and resource accessibility (FAO, 2008).

3. Link between Farmers and Government

Agricultural extension has multiple goals, including transferring knowledge from global, national, and local researchers to farmers, helping them clarify their own goals and assessing their opportunities, educating them about decision-making processes, and promoting desirable agricultural development (Kofi *et al.*, 2015). The knowledge transfer role of agricultural extension has gained traction in the face of increased climatic variability which culminates to weather unpredictability and rapidly changing environmental conditions (Saleh *et al.*, 2016).

4. Improving Farmers Productivity

Agricultural extension plays a role in improving fish farmers' productivity and incomes, thereby reducing poverty and increasing food security. In the event that farmers are involved commercial fish farming, increased productivity provides a pathway of earning income which can be utilised for food procurement (Ragasa, 2014).

5. Ensures Sustainable Aquaculture

Agricultural extension can play a role by ensuring that efforts towards increasing productivity are sustainable. Sustainable fish farming production ensures that current production activities do not compromise the production chances in the future. One way of achieving this is through agro-ecological practices (Feder *et al.*, 2010).

6. Enhances Farmers Income

An increase in farmers' incomes is achieved through market information and linking farmers to markets. Furthermore, training of farmers on product value addition such as smoking and canning can increase their incomes in comparison to marketing of raw fish products (Davis *et al.*, 2010). In addition, extension can link farmers to reliable and cheap sources of aquacultural inputs and outputs, thereby culminating to low production cost and increased income.

Approaches to extension service delivery

"Extension approaches" refers to how knowledge and skills are shared with farmers. This could be done through champion or model farmers, farmer field schools, training, and visits or participatory approach, to name but a few

that have been used in extension (FAO, 2008). Although extension programs may be planned and conveyed in different forms, the ultimate goal remains the same, which is to increase farmers' productivity and income (Waddington et al., 2010). However, the selection of any given combination will depend upon the target farmers' socio-economic and agro-ecological set-up.

1. Individual farm visits

The main purpose of an individual farm visit is to identify and analyze the main problems affecting an individual farmer and to provide advice on the best actions (Davis et al., 2016). The individual farm visit approach is critical in extension service delivery and development. An extension worker may also visit an individual farmer to learn about innovative farm practices or research conducted by a particular farmer.

3. Training and visits

Training and Visits (T&V) is among the earliest methods which concentrated on the transmission of knowledge through a top to the bottom, one-size-fits-all approach. It engaged diverse devices like frequent training of extension workers as well as consistent field visits by contact farmers (Davis et al., 2016).

4. Farmer to Farmer (F2F) Approach

Farmer-to-Farmer (F2F) extension is the delivery of knowledge and information by farmers to fellow farmers, usually using lead farmers and farmer instructors. In this approach, farmers nominated to be principal farmers are usually named model, master, or lead farmers, and are selected founded on their agricultural proficiency (Duflo *et al.*, 2007). Sometimes they are referred to as "farmer promoters" or "trainers", highlighting their interacting and training abilities. F2F is regarded as a worthwhile approach to technology dissemination built on the belief that farmers circulate technologies between peers more proficiently compared to visiting extension workers (Mukasa *et al.*, 2016).

5. Farmer field schools (FFS)

Farmer field schools (FFS) is a participatory approach of teaching, scientific development, and diffusion founded on adult-learning fundamental principles such as pragmatic. In this approach, the farmers gain knowledge through seeing whatever is taking place on the ground and forming groups where they talk about whatever they have grasped, and also through practical field management through to harvest (Braga *et al.*, 2006).

6. Participatory Extension Approach (PEA)

In this approach, the extension worker offers practical information and know-how that is convenient in resolving the recognized problems after the farmers identify the sources of their problems and have known the most demanding ones. Farmer involvement in extension necessitates prioritizing or providing them with actual possession and responsibility of community extension organization (Bembridge, 1999).

7. Commodity Approach

The commodity approach is mostly planned via private sector organizations. In this approach, the production scheme is vertically combined from the contribution source to the knowledge acceptance and selling of the harvest (Hamisu et al., 2017). Farmers produce a particular amount and value of a crop, livestock, or livestock products, and trade with the firm to which they are affiliated. In response, the firm delivers inputs, credit and information amenities, excellent supervision, and marketing facilities.

8. Transfer of technology (TOT)

A lot of extension schemes depend on innovations and data that is either obtainable or can be obtained to be utilized by farmers. The TOT extension method depends greatly on the direct perception of knowledge transmissions, such as the transfer of modern innovations and information produced by experts, scientists, and other specialists. It is conveyed to farmers by agricultural extension workers to enhance production revenue through a top-down mechanism (Suvedi, 2011).

9. Farmer-based extension organizations

In most developed nations, farmers' organized associations have instituted and run extension agendas in agriculture to attend to the desires of the participating farmers (Suvedi, 2011). The extension schemes usually work under diverse administrative arrangements as well as with diverse sources of monetary assistance subject to the country.

Generally, the members of these associations, and not the government, control the functioning of the extension scheme (Suvedi, 2011).

10. Information and communications technology (ICT)

ICT as an extension methodology can accelerate the procedure of agricultural knowledge transmission from research and development institutions to farmers (Dillon, 2012; Duflo et al., 2007; Tata & McNamara, 2016). ICT increases acceptance of agricultural innovations by aiding farmer education, problem-solving, and ease of access to lucrative marketplaces for their produce (World Bank, 2011).

Tools used in extension service delivery

“Tools” refers to the technologies used to transmit knowledge and information, such as radio, podcasts, mobile phones, and demonstrations, etc. Extension tools are hence separated into individual (one-on-one services through face-to-face interactions, phone, or Internet) as well as group approaches (Davis et al., 2016).

Some of the tools that could be used are as following:

- Face to face interaction
- Use of phones
- Transmission media like radio and television
- Social media handles such as Face book, Twitter, YouTube, and others
- Print media
- Use of bill boards
- Use of demonstration farms

Conclusions and Recommendations

The roles and different approaches used by the extension agents in the development of aquaculture in Nigeria were clearly elucidated. Extension services need to clearly articulate their roles in the face of rapidly changing rural and aquacultural context to activate the developmental strategies needed to increase aquaculture production in Nigeria. By and large there is a need for effective public relations in fisheries especially in the aspect of culture fisheries. There is a need for more funding, more planning and more in the part of government, relevant institution and other stakeholders and donor agencies. Funding of extension management and administrative is necessary and crucial. Also, the stakeholders are to be properly linked to institutions for training in fisheries.

References

- Adamu, B. (2007) “Trade and Investment Opportunity in Agriculture”, A paper presented at the India Africa Agric. Food submits in New Delhi, 7 – 8 th March 2007.
- Ajana, A. M. (2002) “Overview of highlight and problems of fisheries extension in Nigerian Agriculture”, Nigeria’s Pioneer Agriculture News Reporting and Trade Promotion Magazine, Vol. 4 (1): pp. 27–32.
- Akpabio, I. A., Okon, D. P., & Inyang, E. B. (2007). Constraints affecting ICT utilization by agricultural extension officers in the Niger Delta. *The Journal of Agricultural Education and Extension*, 13(4), 263–272.
- Anaeto F.C., Asiabaka C.C., Nnadi F.N, Ajaero J.O, Aja O.O,Ugwoke F.O, Ukpongson M.U1, Onweagba A.E (2012). The role of extension officers and extension services in the development of agriculture in Nigeria. *Wudpecker Journal of Agricultural Research* Vol. 1(6), 180 – 185.
- Anastasioa, M., Koutsouris, A., & Konstadinos, M. (2010). Information and communication technologies as agricultural extension tools: A survey among farmers in West Macedonia, Greece. *The Journal of Agricultural Education and Extension*, 2010(16), 249–263.
- Anderson, J. R. (2007). Agricultural advisory services. Background Paper for the World Development Report 2008. The World Bank
- Birner, R., Davis, K., Pender, J., Nkonya, E., Anandajayasekeram, P., Ekboir, J., Mbabu, A., Spielman, D., Horna, D., Benin, S., & Cohen, M. (2006). ‘From “Best Practice” to “Best Fit”’: A framework for analyzing pluralistic agricultural advisory services worldwide’, DSGD Discussion Paper No. 37, IFPRI. *Journal of Agricultural Education and Extension*, 15 (4), 341–355.
- Braga, R., Labrada, R., Fornasari, L., & Fratini, N. (2001). Manual for training of extension workers and farmers on alternatives to methyl bromide for soil fumigation, FAO and UNEP 2001.

- Chambers, D. A., Glasgow, R. E., & Stange, K. C. (2013). The dynamic sustainability framework: Addressing the paradox of sustainment amid ongoing change. *Implementation Science*, 8, 117-123.
- Davis, K., Faure, G., Nahdy, M. S., & Chipeta, S. (2009). Institutional changes and challenges for agricultural advisory services in Africa. Theory and practice of advisory work in a time of turbulences. XIX European Seminar on Extension Education, 15–19, Assisi, Italy (pp. 41–45).
- Davis, K., Nkonya, E., Kato, E., Mekonnen, D.A., Odendo, M., Miiro, R., & Nkuba, J. (2010). Impact of farmer field schools on agricultural productivity and poverty in East Africa. IFPRI Discussion Paper 00992. International Food Policy Research Institute.
- Davis, K., Sulaiman, R., Rossouw, D., Kekana, D., Erasmus., M., Els, D., Ngwenya, H., Schwarz, L., & Ernst., N. (2016). Module 2: Extension methods and tools. Forum for Rural Advisory Services (GFRAS).
- Dillon, B. (2012). Using mobile phones to collect panel data in developing countries. *Journal of International Development*, 24(4), 518–527. <https://doi.org/10.1002/jid.1771>
- Duflo, E., Hanna, R., & Ryan, S. (2007). Monitoring works: Getting teachers to come to school. NBER Working Paper No. 11880, 2005; BREAD Working Paper No. 103.
- FAO (2000) FAO Fishery Department Country Profile. Nigeria. FID/CP/NIR Rev. 4 March 2000 11pp.
- FAO. (2008). Farmer field schools on land and water management in Africa: Proceedings of an international workshop in Jinja, Uganda, 24-29th April, 2006. Food and Agriculture Organization.
- Fasasi A. T. (2003) Keynote address of the programme manager of the Ogun State Agriculture Development Programme (OGADEP), Abeokuta at the 1 st Annual Fish Farmers seminar and Training Workshop organized by Fisheries Society of Nigeria (Ogun State Chapter) at OGADep Abeokuta on July 31st 2003. 6pp.
- Feder, G., Anderson, J. R., Birner, R., & Deininger, K. (2010). Promises and realities of community-based agricultural extension. IFPRI Discussion Paper 00959.: International Food Policy Research Institute.
- Hamisu, S., Ardo, M., Makinta, M., Garba, M. M., & Musa, G. (2017). A review on current status of agricultural extension service in Nigeria. *Asian Journal of Advances in Agricultural Research*, 1 (3), 1–8. Article no. AJAAR.34875. <https://doi.org/10.9734/AJAAR/2017/34875>
- John, G., Igwe, P. D., & Abiye, S. R. P. D. (2014). Ict entrepreneurship and small business innovation: A mechanism for sustainability. *European Journal of Business and Social Sciences*, 3(6), 103–112.
- Kofi, J. A., Kwesi, A. I., & Kotei. (2015). Attitude of farmers of their level of involvement in Agricultural extension in Ethiopia: Policy implications. *International Journal of Agricultural Extension and Rural Development*, 2 (6), 131–136. 3254–5428, Full Length Research Paper. doi:10.5897/JAERD2013.0516
- Lasley, P., Padgitt, S., & Hanson, M. (2001). Telecommunication technology and its implications for farmers and extension services extension program. *Technology in Society*, 23(1), 109–120. [https://doi.org/10.1016/S0160-791X\(00\)00039-7](https://doi.org/10.1016/S0160-791X(00)00039-7)
- Mukasa, H., Nalmansi, E., Egeru, A., Ekwamu, R., Atim, P., & Edimu, M. (2016). Promoting farmer entrepreneurship among smallholders in Uganda. Conference paper ,14
- Ragasa, C. (2014). Improving gender responsiveness of agricultural extension. In A. R. Quisumbing, R. Meinzen-Dick, T. Raney, A. Croppenstedt, J. A. Behrman, & A. Peterman (Eds.), *Gender in agriculture: Closing the knowledge gap* (pp. 411–430). FAO, Springer.
- Saleh, J. M., Man, N., Lafta, A. H., Saleh, M. H., Hassan, S., Nawi, N. M., & Kshash, B. H. (2016). A review: Training requirement of agriculture extension officers in Iraq. *Asian Journal of Applied Sciences*, 9(2), 34-40. DOI:10.3923/ajaps.2016.34.40
- Satia, B. P. (1990) “National Reviews for aquaculture Development in Africa”, 29 FAO Fisheries Circular, No. 770.29, Rome, FAO. 193pp. Tobor, J. G. (1992) “The Fishing Industry in Nigeria. Status and Potential for self-sufficiency in fish production”, NIOMR Tech. paper No 54.

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Strategies to Enhance Youth Involvement in Aquaculture Practices in Rivers State, Nigeria

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Abstract

This study evaluated the strategies to enhance youth involvement in aquaculture in Rivers State, Nigeria. One hundred and fifty structured questionnaires were used to obtain data through scheduled interview with youths that are involved in fish farming across the state. Results of the study revealed that the highest factors limiting youth participation in aquaculture have been identified as insufficient funds (44%), this was closely followed by lack of technical know-how (40.0%), while other factors such as lack of interest (4.0%), unstable market price (2.0%), and unfavourable government policy (2.0%) recorded lower values. However, strategies to promote youth participation in aquaculture include provision of grants and loans (40.0%), adequate training (30.0%) provision of inputs and incentives (20.0%), creation of awareness (6.0%), and formation of groups/ cooperative societies (4.0%). Hence, these strategies if properly harnessed can stimulate youth performance in aquaculture production in the state.

Keywords: Fish Farming, Youth, Rivers State, Empowerment

Introduction

Youth can be described as the persons falling between the ages of 15 and 40 years inclusive (UN, 2012). The similar definition was supported by Piqa (1999) and Lindley (1993). Youths are very important resources for every nation especially for sustaining agricultural productivity, an important sector for the development. The youth is a stakeholder in the development process especially in view of the great assets of youth, resilience, resourcefulness and perseverance (UNESCO, 2004). This group of people is over 1.8 billion in the world today, 90% of whom live in developing countries, where they tend to make up a large proportion of the population and needs to be empowered. Unfortunately, this category of people is virtually left out in policies and programmes considerations (FAO, 2015) even though this is a critical stage for this group of people since this is a period of transition into adulthood. For instance, the unemployment rate of this group has increased globally all over the world (UN, 2012) and this has the potential of tempting most of the youth to embark on migration especially to urban centers and beyond since this act creates room for accessing job opportunities. Since this is an important means of improving food security, youth livelihoods and employment.

Youth is an important and vital segment of human resources, which not only today but in future will have to shoulder the responsibility for the development including agriculture and rural sectors. The same was voiced by UNESCO (2004) as Youth “not only the future...is also the present”. To produce enough food for the world’s six billion inhabitants with the aim to give a voice to the world’s one billion youth (15 to 40-year-olds) who with better opportunities for education, training and employment, could funnel their youthful idealism, energy and determination into a positive force for change (Piqa, 1999). Pittman (1991) recommended strengthening the role of youth-serving organizations to reach underserved and marginalized youth, to extend programs and services to underserved youth and to develop within and crosssector collaboration (Skuza, 2004). Youth in aquaculture has been described as a very important structure for land and agrarian reform which will go a long way towards promoting the interest of youth in the agricultural sector of the economy (Felsing et al., 2000). Nwunel (2018), describes youth as the constituent of a potent agricultural development.

Furthermore, Adedoyin (2005) opines that in Nigeria, youth formed a very significant proportion for rural communities for which their existence and potentials are well known. They constitute a large component of a country's population and contributed alot to the development of the nation and in particular their local communities. Also, Adelodun *et al.* (2016) reiterated that youth amount to about 80 million, representing about 60.0% of the total population of the country. This shows that the youth dominates the country in terms of population, but the apathy of the youths towards fish farming has limited their participation in the sector. Presently, it has been observed that the number of youth involved in aquaculture is very small, rather than getting involved in farming activities, a vast population of the youth goes in search of the white collar jobs which a decline in its availability has been the

experience in recent times. For aquaculture to reach its full potential there should be a considerable and active participation of a high percentage of the youth in the sector (Adelodun et al., 2016). Hence, this study evaluated youths' participation in aquaculture activities in some local government areas of Rivers State, Nigeria

Materials and Methods

Area of Study

This study was carried out in Rivers State, in the southern part of Nigeria. The State is divided into three agriculture zones. The three zones are made up of 23 Local Government Areas (LGAS) of Rivers State (Howard, 2007).

Sampling Technique and data Analysis

Random sampling techniques were employed in the selection of the samples. A total of 180 (60 per zone) structured questionnaires were distributed, to youths between the age 18 to 40 years and a total 150 questionnaires were retrieved. Data was collected by use of primary and secondary sources. Primary data was collected by the use of scheduled interview, while secondary sources were done through the use of textbooks and journals in aquaculture. Data from the study was analyzed by the use of descriptive statistics (FAO, 2015).

Results and Discussion

Analysis of factors limiting youth participation in aquaculture activities revealed that the highest factors limiting youth participation in aquaculture have been identified as insufficient funds (44%), this was closely followed by lack of technical know-how (40.0%), while other factors such as lack of interest (4.0%), unstable market price (2.0%), and unfavourable government policy (2.0%) recorded lower values. This result corroborated that of Adelodun *et al.* (2011), who observed a similar trend in Ibadan, Oyo State, Nigeria. This may be due to the fact that youth have some difficulties in securing credit facilities from banks and financial institutions compared to older people. Also, current economy issue in the country has affected aquaculture production adversely as a result of increase in the price of fish feed in the major markets of the state. However, strategies to promote youth participation in aquaculture include provision of grants and loans (40.0%), adequate training (30.0%), provision of inputs and incentives (20.0%), creation of awareness (6.0%), and formation of groups/ cooperative societies (4.0%). This result agrees with the findings of Akinrotimi *et al.* (2011a, 2011b) and Cliffe *et al.* (2011) in some coastal communities of Rivers State. These authors asserted that provision of credit facilities and incentives have the capacity of enhancing aquaculture production by the people.

Table 1: Factors Limiting Youth Participation in Aquaculture

Variables	Frequency	Percentage (%)
Insufficient funds	66	44.0
Lack of interest	6	4.0
Lack of technical know how	60	40.0
Unstable market price	3	2.0
High cost of inputs	18	12.0
Unfavourable Government policy	3	2.0
Total	150	100

Source: Field Survey (2022)

Table 2: Strategies to Promote Youth Participation in Aquaculture

Variables	Frequency	Percentage (%)
Provision of grants and loans	60	40.0
Adequate training	45	30.0
Provision of inputs and incentives	30	20.0
Awareness to stimulate interest	9	6.0
Formation of groups/cooperative societies	6	4.0
Total	150	100

Source: Field Survey (2022)

Conclusion and Recommendations

Based on the result of the study, it was observed that several factors inhibit youths from taking to aquaculture practices in Rivers State. However, the study also identified some strategies that can encourage youth participation in agricultural production enterprises. This will create employment opportunities for the youth, reduce social vices and encourage food security in the State and Nigeria as a whole. It was therefore recommended that: Youths should be mentored and encouraged through provision of loans with less stringent repayment conditions. Also, agricultural production should be linked to the social media to broadcast the communication of innovations in agriculture to youths.

References

- Akpokodje G., Hamcon F. and Erenstein O. (2001). Nigerian's Rice Economy: State of the Act. In the Nigerian Rice Economy in a Comperative World: Constraints and Strategic Choices Final Report presented to West African Rice Development Association (WARDA), Bounce, Cote D'ivoire. 53pp. In Comparative Analysis of Technical Efficiency in Swamp and Upland Rice Production System in Cross River State Nigeria by Idiong C., Damian J. Aguw and Susam B. Ohen. Proceeding of the Farm Management Association of Nigeria (FAMAN) September 18th-21st, 2006, Jos Plateau State. 30-38. Pp.
- Adedoyin, S.F. (2005). Youth and Children Programme in Nigeria. In Adedoyin, S. F.(ed) Agricultural Extension in Nigeria. AESON. 251 Pp
- Adelodun O. B., Bankole A. F., Rafiu R. A., Morawo, B. O. and Ajao, F. S. (2016). Assessment of youths perception towards fish farming in Ibadan Metropolis Research Journal of Agriculture and Environmental Management. Vol. 5(3), pp. 081
- Alliance for Green Revolution in Africa (AGRA). (2015). Africa Agriculture Status Report: Youths in Agriculture in Sub-Saharan Africa. Nairobi, Kenya. Issue No. 3
- Akinrotimi, O.A., O.M.G. Abu and A.A. Aranyo, (2011a). transforming aquaculture form subsistence to commercial level for subsistence development in Niger Delta region of Nigeria. J. Agric. Soc. Res., 11:22-23.
- Akinrotimi, O.A., P.T. Cliffe and I.F. Ibemere, (2011b). integration of rural aquaculture into small scale farming systems in Niger Delta region of Nigeria. Global Approaches Extension Pract., 7:43-48
- Brown, C. K. (1972). Some Aspects of Adoption of Innovation, A Study of Adoption of Improved Agricultural Practices in the Atebubu and Lawra Districts of Ghana. West African Journal Of Agricultural Economics. In Adoption of Agricultural Innovations in Nigeria: A Case Study of an Improved IITA Cassava Technology Package in Anambra State by M.E. Obeta and E.C. Nwagbo in the proceedings of National Farming System Network. 231 - 244 pp.
- Cliffe, P.T and Akinnotimim, O.A (2015). Role of women in fishery activities in some crastal communities of River state, Nigeria. *International Journal of Agricultural Research* 10(1): 24 -32.
- Cliffe, P.T., O.A Akinrotimi and I.F. Ibemere, (2011). promoting women participation in aquaculture as a viable tool for poverty alleviation in the rural areas of Nigerian. Global Approaches Extension Practise, 7:98-108.
- Daramola, A. M. (1991). Postharvest Grain Loss and Evaluation of Grain Smoking for the Control of Storage Insect Pests of Maize. Proceeding of National farming System Network, p109
- Gwanya, T. (2008), Address by the Director-General at the Launch of Youth In Agriculture and Rural Development (YARD) On 20-22 June 2008, Goudini Spa, Western Cape Department of Land Affairs, Republic of South Africa retrieved on 1st september, 2010 at <http://www.land.pwv.gov.za/.../Publications/2008/Speech%20of%20DG%20at%20YARD%20Launch%20Goudini%20Spa.pdf>.
- Emmanuel, O., Chinenye A. I. and Peter, K. O. (2014). Review of Aquaculture Production and Management in Nigeria American Journal of Experimental Agriculture 4(10): 1137-1151
- FAO (2005). Food and Agriculture Organization, Increasing the contribution of small – scale fisheries to poverty alleviation and food security. Technical Guidelines for Responsible Fisheries Nv.10, FAO, Rome.
- Felsing, M., C, Brugere, K.Kusakabe and G. Kelkar, (2000). Women for aquaculture or aquaculture for women? INFOFISH International, 3:34-40.
- Howard, K.T., (2007). An assessment of aquaculture subsector in the states of Rivers, Ondo and Lagos State, Nigeria. A Report for the World Bank, Washington, DC.
- IdrisaY. L., Gwary M. M. and Ibrahim A. (2006). Determination of Adoption of Cassava Farming Technologies in Mubi North Local Government Area of Adamawa State, Nigeria. In Production Agriculture and Technology (PAT), Faculty of Agriculture, Nasarawa State University, Keffi. 16 - 37 pp. National Agricultural Extension and Research Liason Service (NAERLS) (2001). Proceeding of the National Rural Youths Workshop: An Invited Paper. In C. J. C Akubuilu, J. U. Mgbada, I. J. Chidobenem, D. U. Akubuilu,

- and H. C. O. Aniadoh (eds) Sustainable Children-in -Agriculture. 265, 17-49pp National Population Commission (NPC) (2006). Annual Census Report, 1991. Abuja Nigeria.
- Lindley W.I. (1993). The role of land grant universities in the global development of youth. *J. Agric. Edu.* 34(2): 1-10.
- Nwuneli, N. O. (2018). Youth in Agriculture: An Untapped Opportunity for Youth Employment in Nigeria Managing Partner Sahel Consulting. (18): pp 3. <http://sahelcp.com/wpcontent/uploads/2018/04/SahelNewsletter-Volume-18.pdf> National Bureau of Statistics (NBS) (2018). Report of 2006 Census, Lagos, Nigeria
- Piqa J (1999). FAO urges youth to fight world hunger, The Daily Dawn, Pakistan. October 24.
- Pittman K (1991). A Framework for Defining and Promoting Youth Participation. Future Choices Magazine.
- Skuza JA (2004). Site-based youth development programs:reaching understand youth in targetd communities. J. Extension. 42(1).
- UN (2001). Country profiles on the situation of Youth: Pakistan. World Population Prospects, New York. pp. 93.
- UNESCO (2004). UNESCO's Youth Coordination Unit: Strategy for UNESCO's action with and for youth. www.Unesco.org/youth.

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Socio-ecological Effects of COVID-19 Pandemic on Artisanal Fisheries in Niger Delta Region of Nigeria: A case study of Rivers State

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Abstract

The covid-19 pandemic has rapidly spread around the world with extensive social and economic effects. This paper focuses specifically on the implications of the pandemic on socio-ecological characteristics of artisanal fisheries in Niger delta region of Nigeria. This includes marketing, processing and environmental aspects of the sector in different coastal fishing communities in the region. All aspects of fish supply chains are strongly affected by the covid-19 pandemic, with jobs, incomes and food security at risk with negative consequences which resulted in complete shut-downs of some fisheries, knock-on economic effects from market disruptions, increased health risks for fishers, processors and communities, additional implications for marginalized groups, exacerbated vulnerabilities to other social and environmental stressors, and increased illegal, unreported and unregulated fishing in these communities. Government and industry responses are needed to address the immediate economic and social hardships that the crisis is provoking in the fishery sector. Governments also need to maintain long-term ambitions for protecting natural resources and ecosystems, and the viability of fisheries while the crisis still unfolding, there is an urgent need to coordinate, plan and implement effective short and long-term responses. Thus, we urge governments, development organizations, NGOs, donors, the private sector and researchers to rapidly mobilize in support of small-scale fishers, coastal fishing communities and associated civil society organizations to suggest actions that can be taken by each to help these groups respond to the COVID-19 pandemic.

Keywords: COVID-19, Fisheries, Socio-economics, Ecology, Niger Delta

Introduction

In late 2019, an outbreak caused by a novel coronavirus started in China (Smith, 2020). A global pandemic was declared in March, 2020 as COVID-19, the disease caused by the coronavirus (WHO, 2020), escalated outside China (WHO, 2020). In mid-2021, when vaccination campaigns began to show positive effects on the control of the disease in several countries (OECD, 2020), the COVID-19 pandemic caused millions of deaths and hundreds of millions of infections (KPMG, 2020). In Nigeria, the first index case was confirmed on the 27th of February 2020, Nigeria's Centre for Disease Control (NCDC) reported 23,201 confirmed coronavirus cases and 518 deaths (as of March 12, 2021) in Niger delta (NCDC, 2021). To fight the pandemic, governments reacted with measures designed to contain the spread of the virus, especially through measures aimed to reduce social interactions, including lockdowns (Wilder-Smith and Freedman, 2020), travel restrictions (Chinazzi et al., 2020), and limiting people's access to non-essential activities (Storret et al., 2021).

Nigeria and other Nations in the world are under austere pressure to take forceful measures towards controlling the spread of corona virus and mitigating the effect of covid-19 pandemic on affected populations. Several disease preventive and mitigation actions were quickly introduced in the country particularly, the State-mandated lockdown which involves the total cessation of all non-essential movement, suspension of social and economic activities, restriction on public gatherings, school and office closures, as well as the directive for people to stay at home. As necessary as these measures could be, the resulting surge of unintended adverse consequences on the local economy, health systems, traditional livelihoods, food security, material wellbeing, security and the informal sector, have serious implications on the socio-ecological status of artisanal fishermen in Niger-Delta region.

The whole world have been in a state of chaos after the invasion of the hydra headed monster disease that causes trepidation in the global market, called Coronavirus (Corona virus Disease of 2019-COVID-19), spread from Wuhan, China from December, 2019. In fact, the pandemic outbreak is one event that has engraved an indelible mark on the world's history. Unfortunately, the World Health Organization (WHO) asserted that the health crisis in China had no global potential threat but due to the fact that globally, we are entrenched in the concept of

globalization and China being the world's manufacturing centre, the seemingly less risky Chinese Health issue escalated beyond acceptable limit. (PriceandvanHolm,2020; EzeakuandAsongu, 2020).It is eminent that scenarios of disease outbreak such as the COVID-19 has in the time past disrupted human operations in terms of economy, social, academics, agriculture, fisheries, etc. There will definitely be such pandemics or epidemics as the case may be in the future. But the issue is, after COVID-19 pandemic what are the ripple effects and how do we cushion/recover from such effects on different facets of life, in this case on the fisheries and economy of the nation, Nigeria.

According to Bondad-Reantaso et al., (2020), though the aquatic organism were not directly affected by COVID-19 but it has immensely disrupted the aquatic and fishery sectors (Lee, 2004). That is, in areas such as changing demands of consumers, access to market, transportation and international borders closure, etc. Fish plays a vital role in the nutrition of populace, being a cheaper source of proteins, micro-nutrients and omega-3 fatty acids, which are vital in low-income food-deficit countries (LIFDCs) and Small Island Developing States (SIDS) especially the coastal states, where diets are heavily reliant on fish FAO,(2020). In spite of Nigeria's oil resources, agriculture cannot be sidelined in the country's economy, as it plays a major role in providing the main source of livelihood for most Nigerians. 80 percent of the working population from rural and farming households engages in crop and animal production as their main sources of livelihood. It is quite unfortunate that most rural households fall below the USD 1.90/ day (ie.734.39 Naira/day) poverty line, with over 70 percent termed as "very poor," based on a measure of daily per capita expenditures (Bondad-Reantaso et al., 2020).Thus, the importance of fish within the agriculture sector cannot be underestimated, for its potential contribution to alleviating poverty, improving food and nutrition security, reducing youth unemployment and building profitable business ventures, both capture fisheries and aquaculture are gaining increased attention, in both the public and private sectors.

Nigeria as stated above, is one of the resourced based developing countries that was beaten hard by the fluctuations in price of crude oil- which contributes for about 70 percent of her gross domestic product (GDP) and 65 percent of total government revenue due to COVID-19 impact (Adesoji and Simplice, 2020). The aquatic industry or Fishery sector is the main stay of most world economy and provides means of livelihoods for over 10% of the world's population and a source of food for millions especially the developing countries before the pandemic outbreak (OECD ,2020). In Nigeria, there are three main sources of supply/production of fish - the artisanal, which comes from inland rivers, lakes coastal and brackish waters; from aquaculture or fish farms and industrial fishing (Adekoya and Miller, 2004). Before the pandemic outbreak, the supply of these three sources had not been consistent though majority of the aquatic foods from the coastal areas came from the artisanal sub-sector. As a country that is endowed immensely with natural fishery resources that offer great opportunities for fish and other aquatic foods supply through its artisanal and aquaculture sources, Nigerian fisheries contributed 0.88 % to the Agriculture GDP and contribution of Agriculture to country's GDP is 22%. It also recorded that about 8.632m million people in the primary sector and 19.55 million people in the secondary sector (FDF, 2018).In other words, fish and other aquatic foods contribute significantly in impacting the economy in terms of employment, poverty alleviation, foreign exchange earnings, provision of raw materials for animal feeds industry and huge contribution to the gross domestic product (GDP) (Ali et al., 2008). Specifically, according to FDF (2008), the fishery sub-sector employment has over 8 million fishermen, with another 18 million people engaged in fish processing, distribution and marketing, as a result, above 80% of the annual domestic production are taken care of under this sub-sector while the industrial fishing sub-sector that covers the Atlantic Ocean, contributes about 4% of Nigerian annual domestic fish production (Ipinjolu et al., 2014). The aim of this paper is to highlight some of the attendant impacts/aftermaths of COVID-19 and strategies for adoption to sustain the potential of the industry in contributing to the Economic development of the Nigeria.

Effects COVID 19 on Fisheries

Corona virus pandemic has immensely affected artisanal fisheries production and seafood value chain in Niger-Delta and the world at large as fishermen were restricted to have access to little or no fishing activities due to measures put in place by the authorities to curtail the spread of Covid-19 pandemic. There were disruptions in supply chain of artisanal fisheries as well as decline in fishing activities and consumer demand, thus resulting in the hike of prices of fish and other aquatic food. The Covid-19 pandemic effects were also observed to have a decrease effects in the demand by large-scale buyers mainly the hospitality industry such as restaurant and catering services due to the lock-down measures implemented by the government and this lowered the demand for certain fish harvests in Niger-Delta. A decline in domestic demand has been compounded by a collapse in the export markets. The social distance and confinement measures equally led to closure of many fish markets within Niger-Delta and

further affected by border closure. These challenges have created further impact on the sales of captured fresh fish where their demand is domestically needed within Niger-Delta. More so, loss of demand and difficulties in reaching consumers has led to volatile prices. Moreover, the health and safety measures implemented reduced labour mobility across the supply chain.

Pre-existing health, social and environmental conditions in rural areas like the oil resource extraction zones in Nigeria's Niger-Delta region predispose local populations to the more serious complications of coronavirus. A recent brief by SPACES FOR CHANGE and KEBETKACHE WOMEN revealed that the pandemic is exacerbating pre-existing asymmetries and other social and economic rights deprivations in the Niger-Delta region. Years of crude oil exploration and production by different multinational oil companies have resulted in massive pollution, environmental degradation, total or partial destruction of vegetation in many oil-rich communities, yet poor communities, destroying the peoples' ability to live and make a livelihood. According to United Nations Environment programme, the types of chemicals present in crude and refined oils and released during its combustion, may lead to short-term respiratory problems and skin and eye irritation if concentrations are sufficiently high. This finding raises an alarm bell, essentially when placed side by side with the World Health Organization's (WHO's) caution that people with pre-existing non-communicable diseases such as respiratory diseases appear to be more vulnerable to becoming severely ill with the corona virus. The implication is that underlying health conditions often associated with crude oil production predisposes oil-rich communities in Niger-Delta to greater risk of being extremely harmed by the corona virus. Some of the impacts of the pandemic are described as follows:

Impact on Economy

The 3.5-7% of global GDP is blue economy accounts (UNCTAD, 2020). Blue economy channels, those who on a large scale depend on the marine environment, ecosystem and species to generate economic value are being negatively impacted. The pandemic is not limiting global fishing effort. It is also heavy yield of other nautical goods and services, affecting reliant value chain globally (UNCTAD, 2020). The most heavily traded food products in the world are fish and fish products. According to the Food and Agriculture Organization of the United Nations, trading of these products have reduced drastically in most Niger Delta communities.

Reduction in Seafood Supply

Sea food is the most traded food product in the form of fish and fish products in the world. Approximately, 38 percent of seafood entered in international trade. Meanwhile, fishing and fish farming are important at local level for the economy. Many low income countries and that communities that livelihood depend on fish, as well as small island developing states rely on aquaculture for their expenses. Preventions to contain the spread of COVID-19 have caused disruption in both household and international supply chains. The highly perishable products present in additional logistical challenges are live, fresh or chilled fish, which represent 45 percent of fish consumed. Moreover, widespread containment measures can have a notable impact on nations.

Imbalances in Seafood Systems

The seafood system is an interconnected network of producers (formal and informal), distributors, retailers, and consumers. Some supply chains, market segments, companies, smallscale actors and civil society have displayed initial signs of greater resilience than others. Countries with stable economy and high-income have somehow managed the situation by selling frozen seafood and food with a greater shelf life in response to COVID-19-related shifts in food sourcing, however live-fresh and high-value producers selling to restaurants were mainly hard hit.

Increase in Illegal, Unreported and Unregulated Fishing Activities

Fishing in marine environment is also affected probably due to this pandemic. Illegal, Unreported and Unregulated (IUU) fishing and incursions into areas used by small scale fisheries may increase in this duration due to decreased human observer coverage and lapses in monitoring and enforcement (FAO, 2020a). In most communities of the region government priorities have obviously shifted toward pandemic control, cases of heightened illegal fishing activity by foreign vessels have been reported, which directly influence fish stocks and indirectly on small scale fisheries (FAO, 2020b).

Decline in Fishing Pressure

Lastly, in most of the communities of Niger Delta there is decrease in fishing pressure, especially by legal industrial fleets, may enable fish stocks with more strong life histories to recover, with significant indirect effects for the

small-scale sector. For example, the amalgamation of reduced demand, lower prices, and lockdowns on fisheries in many places means that boats are staying in port and fishing is reduced to almost 80% (Korten, 2020).

Affects Food Security

Food insecurity appears to be prevalent across the Niger-Delta region especially in Rivers State. According to the Second Quarter 2020 Labour Force Surveys. The share of households reporting that an adult in the household had to skip a meal since the start of the pandemic was 79 percent in Rivers State while the share of households that ‘ran out of food because of lack of money or other resources’ was 58 percent in Rivers State (Nnabuike, 2020). Households within the artisanal fishermen are struggling to cope with the impact of COVID-19 and are deploying strategies that may have negative long-term consequences on their welfare. In the Niger-Delta region particularly in River State, at least two-thirds of households had spent their savings to cover their living expenses, while others had borrowed money to cover their living expenses. More than 1 in 10 households in Rivers State reported violating containment measures in order to maintain a living. This not only underlines the trade-offs that households may face in trying to balance their economic welfare and their health, but also demonstrates that lockdown measures were not universally followed (Ocampo, 2020).

Uneven Distribution of Social Assistance

Free food was the most common form of social assistance, but its prevalence varied dramatically between the States in Niger-Delta. In Rivers, as many as 43 percent of households reported receiving assistance in the form of free food since the start of the pandemic in mid-March, 2020; compared with just 15 percent of households in Cross Rivers State. Receipts of social assistance in the form of cash were very rare in all the States in Niger-Delta. Although, Overall cross-state differences in the distribution of social assistance do not directly correspond with cross-state differences in the extent of food insecurity (Akanni and Gabriel, 2020).

Conclusion

The analysis suggests that the COVID-19 pandemic presents major challenges for the small scale fisheries sector globally. Although some positive initiatives and outcomes prevail in this condition but they are completely dominated by the negative consequence particularly for groups that are most susceptible to these changes. Moreover, the crisis is far from over. The short-term impacts mentioned are probably to be followed by long-term crises associated to economic hardships and global food crises.

References

- Akanni, L.O., Gabriel, S.C., 2020. The Implication of Covid19 on the Nigerian Economy. Centre for the Study of the Economies of Africa (CSEA). Downloaded on April 15th 2020 from <http://cseaafrica.org/the-implication-of-covid19-on-the-nigerian-economy/>.
- Clavelle, T. (2020). Global fisheries during COVID-19. In: Global Fishing Watch [online]. <https://globalfishingwatch.org/data-blog/global-fisheries-during-covid-19/>
- FAO (2020) WorldFish Nigeria Strategy 2018–2022
- FAO (2020a) Summary of the impacts of the COVID-19 pandemic on the fisheries and aquaculture sector: Addendum to the State of World Fisheries and Aquaculture 2020. Rome. <https://doi.org/10.4060/ca9349en>
- FAO (2020b) How is COVID-19 outbreak the fisheries and aquaculture sectors and what can FAO do.
- FAO, 2020. National Policy Responses to Limit the Impact of COVID-19 on Food Markets. Food Policy and Market Developments. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. Downloaded on April 12th 2020 from <http://www.fao.org/giews/food-prices/food-policies/detail/en/c/1270543/>.
- FDF-(Federal department of Fisheries (2018)
- Federal Department of Fisheries (1995) Federal Republic of Nigeria: Inland Fisheries (Fish Quality Assurance) Regulations.
- Freduah, G., P. Fidelman, and T. F. Smith. 2017. The impacts of environmental and socio-economic stressors on small scale fisheries and livelihoods of fishers in Ghana. *Applied Geography* 89 (December):1–11. doi: 10.1016/j.apgeog.2017.09.009.
- Kittinger, J. N. 2013. Human dimensions of small-scale and traditional fisheries in the AsiaPacific Region. *Pacific Science* 67 (3):315–25. doi: 10.2984/67.3.1.
- KPMG, (2020). “Covid-19: A Business Impact Series- Economic impact and Pandemic Planning”. KPMG Covid-19 Publication, Issue 1, pp 1-4.
- Lee J-W and McKibbin, W. (2004). Globalization and Disease; The Case of SARS’ *Asian Economic Papers* Vol. 3. no 1. MIT Press Cambridge USA. pp 113-131 (ISSN 1535-3516).

- NCDC (2021).NCDC updates-Case summary in the Niger delta as at March 12, 2021.
- Nnabuife, C. (2020). COVID-19: FG Commences Process to Distribute 70,000 Metric Tons of Food Items. Tribune. April 4, 2020 <https://tribuneonline.ng.com/covid-19-fg-commences-process-to-distribute-70000-metric-tons-of-food-items/>.
- Ocampo, K. R. 2020 Fishing communities bear brunt of lockdown inquirer business.philipine Daily Inquirer, April 5, 2020.
- OECD (2020), COVID-19 and International Trade: Issues and Actions, OECD Publishing, https://read.oecdilibrary.org/view/?ref=128_128542-3ijg8kfsw&title=COVID-19-and-international-trade-issues-andactions.
- Onyekwena, C., and Amara M, E., 2020. Understanding the Impact of the COVID-19 Outbreak on the Nigerian Economy. Brookings Institution, Washington, DC. Downloaded on March 30th 2020 from <https://www.brookings.edu/blog/africa-infocus/2020/04/08/understanding-the-impact-of-the-covid-19-outbreak-on-the-nigerianeconomy/>.
- Rosenberg, M. S., (2005). “The file-drawer problem revisited: a general weighted method for calculating fail-safe numbers in meta-analysis”, *Evolution*, 59(2), pp. 464-468.
- Smith, E. 2020. Lunenburg lobster captain sells directly to consumers to stay afloat during COVID-19. CBC News, April 6, 2020. <https://www.cbc.ca/news/canada/nova-scotia/gail-atkinson-lobster-fishery-covid-19-nova-scotia-1.5523635>.

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Constraints Limiting Women Performance in Aquaculture in Nigeria

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Abstract

Aquaculture plays a critical role in food and nutrition security, economic empowerment and creation of employment opportunities for millions of people. However, the benefits from aquaculture are not evenly distributed between men and women due to gender-based constraints which limit maximum returns. Women play a key and vital role in the Fisheries value chain in Nigeria especially when we look at their involvement in the marine, artisanal and Aquaculture sub-sector of the Fisheries. Their participation in terms of number and output have been limited due to some constraints affecting their productivity. The present study reviewed constraints limiting women performance in fisheries and aquaculture in Nigeria. Therefore, abolishing these constraints is imperative in increasing production for development and social wellbeing of not only women but the entire household, community and the nation at large.

Keywords: Women, Fisheries, Aquaculture, Food security, Constraints

Introduction

In Nigeria, the involvement of women in fisheries and aquaculture practises has attracted greater attention in recent years. This is in recognition that women play significant roles in Nigeria's fisheries production, processing and utilization (Cliffe and Akinrotimi, 2015). On the average, women contribute 43% of the agricultural sector labour force in developing countries, ranging from about 20% in Latin America to almost 50% in East and South-east Asia and Sub-Saharan Africa. In many African countries, up to 80% of farm labour is provided by women (FARM AFRICA, 2016). This necessitates their integration into planning, policies and programs for effective and sustainable development of a nation. Hence, the role of women in agricultural production in developing nations cannot be overlooked (Barau and Oladeji, 2017). Women play prominent roles in fish farming. They participate extensively and actively in all phases of work performed in fish farms. Their participation in aquaculture related activities extends to every aspect of fish farming such as preparation of fish feed, feeding of fish, general maintenance and upkeep of ponds or cages. They also engage in fish harvesting, sorting of fingerlings and pond stocking (Wara *et al.*, 2007). Many women are farm owners and managers across the country. They are actively involved in the entire aquaculture value chain from the farm to the final consumer.

Despite their tremendous contributions in the field of aquaculture, women in Nigeria are facing a lot of problems which to a large extent limit their potentials in aquaculture. Some of these problems include lack of access to credit, lack of access to information technology, lack of access to land, family dependence, restriction to family business with limited leadership role, lack of access to market, poor linkages to supportive services, finance, undue competition from larger and established agribusiness units, cultural inhibitions, discrimination of all sort, transportation facilities, competing family responsibilities among others (Ayogu and Agu, 2015). These problems have reduced remarkably the volume and variety of production and employment possible for women. Women across the developing world are disadvantaged relative to men. Since women constitute majority of the populace. According to Cliffe and Akinrotimi (2015), fish production is mostly considered as masculine venture, though women role in fish related activities is imperative and indispensable. However, women role is repeatedly being ignored and relegated, as a result of the primordial systems of social setting that is prevalent in the rural areas of many developing countries like Nigeria (Ibrahim *et al.*, 2011). This paper therefore reviewed various constraints limiting women participation in aquaculture and proffers some possible solutions on how to combat it.

Roles of Women in Aquaculture

Women play different roles in aquaculture, these ranges from fish farming to processing, and marketing. They operate between the farm and the final consumers. Women participate not only in the traditional fisheries sectors of fish processing and marketing, but also in the non-traditional sectors of aquaculture, fisheries research, education

and extension. Women dominate the subsistence fishing sector, with increasing involvement in the local commercial fishery. As fishers for home consumption, women contribute significantly to the nutritional needs of the family. Their Functions and roles are discussed and presented as follows:

1. Fish Farming

Women are involved in different aspects of fish farming such as fish breeding, stocking, feeding, monitoring of water quality and fish growth till harvesting. They are involved either on part time or full time basis. Also, some practised fish farming on commercial or at subsistent level.

2. Fish processors

Fish processors actively participate in the marketing of fish. The major role of these participants is the change in form and value addition to the product. The processors create utilities of form and time by changing the fresh fish to smoke-dried or sun-dried form. When processed the fish gain more shelf-life. Thus it could be stored and marketed over longer period of time and space (Adebayo and Pitan, 2001).

3. Fish Suppliers

Many women are into supply of fresh and processed fish whether smoke dried or sun-dried from the processors to the consumers. Some of them carry out this function through commission agents to the urban wholesalers, retailers and then consumers in the urban centres and so on (Aquilari, 2002).

4. Fish Traders

Several women in different parts of the country are involved in trading of fish from aquaculture as a commodity in the open market. Fish traders are another set of important participants in the value addition chain analysis of fresh water fish. They take specific roles in the marketing of different forms of fish within and outside the State. Traders are not involved in fishing or processing of fish with few exceptions which include reprocessing of fish to maintain its value pending the time of sale.

5. Commission Agents

Ladu et al (2013), Stated that, Commission agents play prominent role in the value addition chain analysis of fish especially the processed form. They also play a vital role in the bulking of fresh fish for regional marketing. Commission agents in the marketing of different forms of fresh water fish (like other commission agents) do not take title to the product but rather act on behalf of other traders along the marketing channels. They form the link between many intermediaries in the marketing channels. Among the roles played by this agents include provision of market information (price and demand) to women processors.

Constraints Limiting Women Performance in Fisheries and Aquaculture

The constraints faced by women in fisheries and aquaculture are numerous, these include the following:

1. Inadequate capital

Besides women, face stiffer constraints compared to men when it comes to access to factors of production which are often owned by men as head of the household and therefore the sole decision-makers (KMFRI, 2017). This limitation further constrains women's ability to access credit facilities since these assets form collateral. As a result, women's contribution is not commensurate to the benefits they enjoy from fish farming. The bureaucratic bottlenecks like collateral securities have further aggravated the situation, hence the need to train the women. Past workers have confirmed women as being better managers of funds than their male counterparts Women repay loans faster than their male counterparts (most of whom divert loans to ostentatious transactions (Williams, 2006) .

2. Inadequate land for expansion

Many communities especially in the rural areas of Nigeria consider it a taboo to give land to women. This practise makes it difficult for women to acquire land for fish farming. Nigeria being a patrilineal society unlike Ghana and Rwanda, rural women are often disadvantaged in terms of land accessibility. Only in very few States can women own land. The land tenure system does not favour women. Changing the land tenure system could greatly affect the status of women, thus making them to go into fish farming (Williams, 2006).

3. High cost of fish pond establishment

The high cost of constructing and building concrete tanks and earthen ponds have increased tremendously in recent times, thus forcing many women to abandon fish farming in different parts of the country.

4. High cost of feeds

The cost of feed has risen astronomically in recent years, thereby forcing many women to abandon their farms.

5. Dominance by spouse/Gender Inequality

Persistent differences and disparities between men and women can result in overburdening women with too much work but fewer benefits from the same with negative implications for the family and the whole society

(Williams, 2006). This is especially true when women are constrained by inequality and discrimination (Oyediran *et al.*, 2016).

6. Inadequate technical know-how

This apathy towards women as equal partners in progress also contributed to the higher illiteracy level among female fisher folks. The age-old belief that women are weaker and meant only for procreation and culinary function should stop in the new millennium (Williams, 2006).

7. Omission of Women from Planning, Implementing and Monitoring Of Conservation Initiative

The varying threats of women in aquaculture include omission of women from planning, implementing and monitoring of conservation initiative in accordance with cultural norms where the cultural norms may appear prohibitive and adaptive to the support of women engagement in natural resource management. Women are not proportionately represented in the unpaid labour force. Several cultural forces have been used in the past to keep women away from the fishing trade (Gopal *et al.*, 2014).

Strategies that will Enhance Women Participation in Aquaculture

Women play an important role in aquaculture sector. This role encompasses social and economic activities and duties, both within and outside the family. In spite of this, presence of women in aquaculture sector is very negligible due to some social and cultural stigma.

The following suggestions may improve the situation:

1. Women should be allowed to have Equal Access to Resources

Addressing inequalities in gender, by exposing women to equal access to resources and opportunities like men increases farm production and raises agricultural output which is beneficial to the entire family (Gallant, 2019; FAO, 2011; Weeratunge-Starkloff and Pant, 2011). Since gender equality is enshrined in the Sustainable Development Goal (SDG 5) of the United Nations as a crucial target to be met by 2030 (FAO, 2011), its achievement in agriculture is indispensable (Me-Nsope and Larkins, 2015). Weeratunge *et al.* (2012) and FAO (2013) emphasized the importance of eliminating hurdles limiting women's control over access to assets and gender norms to attain gender equality. Additionally, Schumacher (2014) and Kruijssen *et al.* (2018) proposed a gender perspective in value chain analysis to mitigate the gender differences in aquaculture and increase production and returns. This entails an assessment of roles performed by men and women, and how they relate with each other; which dictates the possibilities of counteracting constraints and reaping maximum benefits from the venture. This suggestion is envisaged to encourage women's participation in the aquaculture value chain since they complement men for improved productivity and income, as well as promote gender equity (HLPE, 2014).

2. Adequate Training should be Provided for Women

Spreading education among women especially farm women requires urgent attention. Location specific and basic training programmes should be organized because women's role in aquaculture is widely recognized. Adopting flexible timings and training approaches would encourage more women to participate in training sessions. In Vietnam, it was noted that after such training women became 'aquaculture specialists' in the household (Voeten and Ottens, 1997). Nwabueze (2010) suggested that women should be empowered through education, training.

3. Provision of loans and Credit facilities

Women should be encouraged by providing access to loan to enable them participate in aquaculture development. Develop women-friendly aquaculture technologies so that they can involve themselves in carp culture business, seed rearing, composite carp culture, integrated fish farming and design special nets convenient for women farmer to harvest fish.

4. More Women should be appointed as Extension Agents

Appointing more women trainer/extension worker can give better result in technology transfer by avoiding social hindrances. This would result in providing better access to technology as well as render transfer of technology efforts more successful. Felsing (2001) suggested that organizing women's aquaculture club and implementing aquaculture extension through women union would improve women's access to information.

5. Document Women Success Stories

Success stories of women need to be documented and more research efforts on gender in aquaculture are required. Enabling policy environment must be in place to avoid gender discrimination in wage and work environment. Gender-disaggregated data and information are essential (Razavi and Miller, 1995) to understand their importance in productive enterprises such as aquaculture or to promote equity and women's rights.

Conclusion and Recommendations

Women involvement in fish farming is besieged by several bottlenecks, which includes inadequate capital, inadequate land for expansion and high cost of fish pond establishment. Encouraging active women participation in fish farming requires that these constraints be adequately addressed. Hence, the government and financial institutions should give loans to active and registered women fish farmers at considerable interest rates but with proper monitoring to ensure its effective use for the purpose so as to increase their production levels and profitability.

References

- Adebayo O, & Pitan O.O (2001). Role of women in marketing of frozen fish in Lagos state. Annual Conference of Fisheries Society of Nigeria Proceedings, pp. 435-437.22.
- Aquilar, L (2002). Fisheries and aquaculture in coastal areas. Gender makes the difference. IUCN Briefing Notes, Geneva.
- Ayogu, D.U. and Agu, E.O. (2015). Assessment of the contribution of women entrepreneur towards entrepreneurship development in Nigeria. International Journal of Current Research and Academic Review, 3(10): 190 – 207.
- Barau, A. A. and Oladeji, D. O. (2017). Participation of urban women in agricultural production activities in the Sokoto Metropolis, Nigeria. Journal of Natural Resources and Development; 7: 84- 90.
- Cliffe PT, Akinrotimi OA (2015) The Role of Women in Fisheries activities in Some Coastal communities of Rivers State. *International Journal of Agricultural Research*, 10: 24-32.
- FAO (2012) Strategies for Sustainable Animal Agriculture in Developing countries. Proceedings of the FAO Expert Consultation, Animal Production and Health Paper 107. 26.
- FARM AFRICA (2016) Gender Impact Study of the Kenya Market-Led Aquaculture Program. <https://www.farmafrica.org/downloads/resources/farm-africas-kmap-gender-impact-study.pdf>
- Gopal N, Williams M J, Porter M, Kusakabe K and SzeChoo P (2014). Gender in Aquaculture and Fisheries. Asian Fisheries Science, (27S), 1–265. Retrieved from <http://s3.amazonaws.com/academia.edu.documents/36931880/2014-12-22-01>
- Ibrahim, H.I, Kigbu, A.A and Mohammed, R (2011). Women experience in small scale fish processing in lake Feferuwa fishing community, Nasarawa State, Nigeria. *Livestock Research For Rural Development* 23(3):1-8
- KMFRI (2017). Kenya's Aquaculture Brief 2017 Status, Trends, Challenges and Future Outlook. African Journal of Food, Agriculture, Nutrition and Development. https://www.kmfri.co.ke/images/pdf/Kenya_Aquaculture_Brief_2017.pdf
- Oyediran, W.O., Omoare, A.M., Oladoyinbo, O.B., Ajagbe, B.O. and Dick, T.T. (2016). Constraints Limiting the Effective Utilization of Low-Cost Fish Processing Technologies among Women in Selected Fishing Communities of Lagos State, Nigeria. *Fisheries and Aquaculture Journal*, 7(4): 1-5.
- Wara A, Nwabeze GO, Tafida AA, Abubakar SM (2007) Women in Fisheries: A case study of the Kainji Lake Basin, Nigeria. Proceedings of the Fisheries Society of Nigeria, p. 66- 67.21.
- Williams, S.B (2006). The Socio-economic potentials of women in Riverine small scale fisheries in Nigeria. Department of Agricultural Economics, Obafemi Awulowo University. Ile-Ife, Osun State, Nigeria.

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Antimicrobial susceptibility profile of Bacteria Isolates from Cultured Catfish at Ibeju-Lekki fish farms Lagos

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Abstract

Antibiotics usage in fish production offers a selective pressure and thus creates reservoir of multiple drug resistant bacteria in the cultured fish and their environment. The aim of this study was to determine the antimicrobial susceptibility profile and multiple antibiotics resistance index of bacterial isolates from cultured catfish from Ibeju-Lekki fish farms in order to identify high-risk sources of contamination and address the issue of emerging antibiotics resistance commensal bacteria from fish farming. Ten different bacterial species were isolated from fifty catfish samples from Ibeju-Lekki fish farms, and identified using standard microbiological biochemical test. Their antimicrobial susceptibility profiles were determined using Kirby Bauer disc diffusion method. Multiple antibiotics resistance was recorded from the results, as bacterial isolates were observed to show the highest level of resistance towards Augmentin (90%), followed by Streptomycin (80%) and Gentamycin (70%) respectively. Moreover, all the bacterial isolates were confirmed to be 100% susceptible to Cotrimoxazole and Ciprofloxacin antibiotics, followed by Rifampicin (90%), Erythromycin (90%) and Norfloxacin (80%). However, Multiple Antibiotics Resistance (MAR) Index of the isolates in this study ranged from 0.2 to 0.6. *Klebsiella oxytoca* had the highest of Multiple Antibiotics Resistance Index of 0.6 followed by *Escherichia coli* with 0.5 MAR index, indicating high antibiotics usage from the sample where they were isolated from. while *Flavimonas oryzae* had the lowest MAR index of 0.2. The abuse of antibiotics has immensely contributed to the high incidence of multiple drug resistant bacteria isolated from this study. Therefore, treatment guidelines for use of antibiotics should be implemented to avoid indiscriminate use of antibiotics and there should be periodic review to ensure the rational use of antibiotics by veterinarians and fish farmers in the treatment of fish diseases.

Keywords: Antimicrobial, catfish, commensal, pathogens, resistance.

Introduction

The indiscriminate use of antibiotics and abuse of it by fish farmers and others in animal rearing enterprises have led to a significant increase of resistant microbes around the globe. These antimicrobial usage have been widely utilized with the sole aim of serving as a therapeutic or prophylactic purposes in fish farming industry (Manyi-Lohet *et al.*, 2018). Nevertheless, these antibiotics are generally applied to increase and fasten the growth of fish and as well for effective feed efficiency in the fish (Muhammad, *et al.*, 2020).

There are major concerns surrounding antimicrobial agent's usage in farm-raised fish, including the potential impacts their usage may have on the development of antimicrobial-resistant pathogens in fish and the aquatic environment. Conversely, some antibiotics such as Oxytetracycline, Chloramphenicol, Nitrofurans, Tetracycline (Kathleen *et al.*, 2016), Erythromycin, Enrofloxacin, Streptomycin (Ademola *et al.*, 2009) have been used more frequently than others in both human and Veterinary medicine. The development of antibiotic resistance by bacteria has always been hastened specifically by selective pressure as a result of overuse and incongruous antibiotics usage and possession of plasmid by some bacteria (Akond *et al.*, 2009). In an attempt to cope and provide solution to the menace of antibiotics resistance, scientific researcher have speeded up the search for alternative antimicrobial agents by screening different natural potential sources such as the medicinal plants (Gislene *et al.*, 2000) and microbes (Sethi *et al.*, 2013).

The menace of antimicrobial resistance is more rampant and serious in developing countries where antibiotics are widely used off label. In Nigeria, antibiotics are extensively applied in both aquaculture and animal husbandry. All resistance to antibiotics by microbes has genetic basis (Abu and Wondikom, 2018), because it is part of bacteria defence mechanisms which enable them to thrive in a hostile environment (Gang *et al.*, 2015). Several bacterial species have evolved in transferring their virulence genes to other different bacteria that are not of the same species thereby creating a new pathotypes as a result of the combination of different virulence genes (Sarowska *et al.*,

2019). A danger of bacteria resistance to antibiotics exists among 5 to 10% of the infections cases treated that lead to lack of success or prolonged treatment (Frieriet *et al.*, 2017). Cases of bacteria resistance to antibiotics have increased the risk of mortality and transmission of diseases consequently due to their adaptation towards different aqua media (Serweciska, 2020). This has been attributed to horizontal gene transfer of plasmids and other mobile genetic element (Bello-Lopez *et al.*, 2019). Antimicrobial usage must therefore be carefully regulated and monitored in animal husbandry and in our environment (Feiyanget *et al.*, 2020), in order to be able to evaluate their impact and subsequent risk to the ecosystem. This study was undertaken to investigate the occurrence of Antimicrobial resistance of bacteria isolates from cultured catfish at Ibeju-Lekki fish farms in Lagos in order to identify high-risk sources of contamination and address the issue of emerging antibiotics resistance commensal bacteria from fish farming.

Materials and Methods

Study area

Juvenile fish samples weighing 45 to 50 grams were collected from five different fish farms within Ibeju-Lekki area of Lagos State namely: Lakowe, Okegun, Alatise, Bogije and Onosa.

Collection and Processing of Sample

Fifty fish samples collected from five different fish farms were transported in an iced container within six hours to the laboratory for bacteriological analysis which was carried out at Aquaculture Laboratory of Nigerian Institute for Oceanography and Marine Research, Lagos from 08/01/2019 to 29/03/2019. The samples were dissected using a dissecting kit in an aseptic manner.

Characterisation of Bacterial Isolates

The skin, gills and the intestine of the dissected fish were aseptically swab, and were streaked on already prepared sterile petridish containing Nutrient agar (Himedia, India). It was incubated at 30°C for 18 hours and were observed for distinct colonial growth of bacteria. Thereafter, distinct colony was further sub-cultured on a fresh media in order to obtain pure culture of the isolates. The isolated bacteria were identified using their Gram stain reaction and series of biochemical tests.

Antibiotic Susceptibility Studies

Antibiotic susceptibility was done using commercially sold antimicrobial sensitivity test single disc from Oxoid Ltd, Basingstoke, RG248PW, United Kingdom. Pure culture of the isolated bacteria were taken from Nutrient broth using a sterile wire loop and transferred to 5 ml tubes containing sterile physiological saline. The suspension was vortexed and adjusted to match 0.5 McFarland turbidity standards (Cockerill, 2012). Thereafter, sterile swab stick was then dipped and pressed firmly on the tube walls above the culture in order to remove excess inoculum. Subsequently swabbed on the surface of Mueller-Hinton agar (Oxoid Ltd., England) plates ensuring even distribution of the bacterium using Kirby Bauer disc diffusion method (Donald *et al.*, 2013). Ten antibiotics corresponding to drugs most frequently used in the treatment of both animal and human infections caused by gram positive and negative organisms were used. The antimicrobial susceptibility single discs were placed on the plates using sterile forceps and were incubated at temperature of 30°C for 24 hours, after which the diameter of zone of inhibition were measured with white transparent meter rule in millimetre. Degree of susceptibility of each test organism to each antibiotic was determined and interpreted as either sensitive or resistant. The methods describe above and the interpretations of results were done using standard recommended by Clinical Laboratory Standard Institute (CLSI, 2016). Different antibiotics used and their concentration includes: Ciprofloxacin (Fluoroquinolones) 10µg, Cotrimoxazole (sulphonamides) 30µg, Streptomycin (Aminoglycosides) 10µg, Gentamycin (Aminoglycosides) 10µg, Rifampicin (Ansamycin) 20 µg, Ofloxacin (Quinolones) 10µg, Norfloxacin (Fluoroquinolones) 10µg, Erythromycin (Macrolides) 30µg, Pefloxacin (Quinolones) 10µg, and Augmentin (β-lactams) 30 µg.

Determination of Multiple Antibiotics Resistance Index

Multiple antibiotic resistance index were determined as described by Samuel *et al.* (2011), for each bacterial isolates by dividing the number of antibiotics which the bacterial isolates were resistant to with the total number of all the antibiotics tested. Multiple antibiotics index is a measure used to identify the risk of contamination that poses potential hazard to human. However, multiple antibiotics resistance value greater than 0.2 is a signal that the bacterial isolates were from high risk sources (Nyandjou *et al.*, 2019).

Results

The result for the isolation and characterization of bacterial from this study is shown on Table 1. Antibiotics susceptibility profile of bacterial isolates and their corresponding multiple antibiotics resistance index from this study is shown in Table 2. The bacterial isolates were observed to show the highest level of resistance towards Augmentin (90%), followed by Streptomycin (80%) and Gentamycin (70%) respectively. Moreover, all the bacterial isolates were confirmed to be 100% susceptible to Ciprofloxacin and Cotrimoxazole antibiotics, followed by Rifampicin (90%), Erythromycin(90%) and Norfloxacin (80%). The percentage of resistance of the bacterial isolates to a particular antibiotics tested is shown in Table 2.

The occurrence of Multiple Antibiotics Resistance (MAR) Index in this study (Table 3) ranged from 0.2 to 0.6. *Klebsiella oxytoca* had the highest of Multiple Antibiotics Resistance Index of 0.6) followed by *Escherichia coli* with 0.5, while *Flavimonas oryzihabitans* had the lowest MAR index of 0.2.

Table 1: Biochemical Test of Bacterial Isolates.

Test															Organism isolated
Organ	Gram reaction	morphology	Motility	Oxidase	Glucose	Lactose	Maltose	H ₂ S	Gas production	Citrate	Methyl red	Voges-proskauer	Indole	Nitrate reduction	
Gill	-ve	rod	+	-	+	-	-	-	-	-	+	-	+	-	<i>E. coli</i>
Gill	-ve	rod	+	-	+	-	-	-	-	-	+	-	+	-	<i>Klebsiella oxytoca</i>
Skin	-ve	rod	+	-	+	-	-	-	+	-	+	-	+	-	<i>Morgenella morganii</i>
skin	-ve	rod	+	-	+	+	+	+	-	+	+	-	-	+	<i>Proteus specie</i>
Gill	-ve	rod	+	+	+	+	+	+	-	+	-	+	-	+	<i>Enterobacter specie</i>
Skin	-ve	rod	+	-	+	-	-	-	+	+	-	+	+	-	<i>Serratia marcescens</i>
Gill	-ve	Short-rod	+	-	+	+	+	-	-	+	-	+	-	+	<i>Aeromonas specie</i>
Skin	-ve	rod	-	+	+	+	-	-	-	+	+	-	-	-	<i>Shigella sonnei</i>
Gill	-ve	Curve-rod	+	-	+	-	-	+	+	-	-	-	+	-	<i>Vibrio sp.</i>
Skin	-ve	rod	+	-	+	-	-	-	+	+	-	-	+	-	<i>Flavimonas oryzihabitans</i>

Note: + = positive reaction, while – means negative reaction.

Table 2: Antibiotics susceptibility profile and Multiple Antibiotics Resistance Index of the isolated bacteria

Isolates Codes	Bacterial species	Antibiotics										MAR Index
		CIP	COT	S	G	R	O	N	E	P	A	
AL01	<i>Serratia mercenscens</i>	S	S	R	R	S	S	S	S	R	R	0.4
LK02	<i>Proteus sp.</i>	S	S	R	R	S	S	S	S	S	R	0.3
OK03	<i>Morganella morgani</i>	S	S	R	S	S	S	R	S	S	R	0.3
BJ05	<i>Shigella sonnei</i>	S	S	S	R	S	R	S	S	R	R	0.4
ON03	<i>Enterobacter specie</i>	S	S	R	S	S	R	S	S	S	R	0.3
LK04	<i>E. coli</i>	S	S	R	R	S	R	S	S	R	R	0.5
OK01	<i>Klebsiella oxytoca</i>	S	S	R	R	S	R	R	R	S	R	0.6
AL04	<i>Aeromonas specie</i>	S	S	R	R	S	S	S	S	S	R	0.3
ON01	<i>Flavimonas oryzihabitans</i>	S	S	S	S	S	R	S	S	S	R	0.2
BJ03	<i>Vibrio specie</i>	S	S	R	R	R	S	S	S	S	S	0.3

N/B: S=Susceptible, R=Resistance, CIP= Ciprofloxacin, COT= Cotrimoxazole, S= Streptomycin, G= Gentamycin, R=Rifampicin, O= Ofloxacin, N= Norfloxacin, E= Erythromycin, P= Pefloxacin, A= Augmentin.

Table 3: Percentage of resistance to antibiotics of bacterial isolates from catfish from Ibeju-Lekki Fish Farms

Antibiotics	Number of resistant isolates (%)
Ciprofloxacin	0 (0%)
Cotrimoxazole	0 (0%)
Streptomycin	8 (80%)
Gentamycin	7 (70%)
Rifampicin	1 (10%)
Ofloxacin	5 (50%)
Norfloxacin	2 (20%)
Erythromycin	1 (10%)
Pefloxacin	3 (30%)
Augumentin	9 (90%)

Discussion

Antibiotics resistance menace that is associated with fish farming has become a significant area of research focus in recent time. As more fish farmers engage in fish farming at industrial level, it has made aquaculture production more susceptible to the challenge of controlling disease outbreaks in their fish farms. Therefore, understanding the status of antimicrobial resistance of bacterial isolates from fish is paramount for accurate monitoring of the trend of development of antibiotics resistance in the ecosystem across the world. The bacterial isolates from this research were 100% susceptible to only two classes of antibiotics (Cotrimoxazole and Ciprofloxacin) out of ten antibiotics tested. The bacteria resistance was more prevalent in Augumentin, Streptomycin and Gentamycin and this result is in partial agreement with the report of Abu and Wondikom (2018), who reported antibiotics resistance of bacterial isolates to Augumentin and gentamycin in their study on the isolation, characterization and antibiotic resistance profile of bacteria from an excavated pond in Port Harcourt metropolis in Nigeria and similarly in contradiction with the work of Abraham (2011), who reported that *Escherichia coli*, *Vibrio sp.* and others were sensitive to Gentamycin and resistant to Cotrimoxazole in his study on the food safety hazards related to emerging antibiotic resistant bacteria in cultured freshwater fishes of Kolkata, India. Multiple antibiotics resistance were likewise

observed from this study as the bacterial isolates shows various degree of resistance to eight different antibiotics, in agreement with the finding of Ogbonne *et al.* (2019) who reported bacterial isolates resistance to different class of antibiotics from their studies on genotypic characterization and resistance patterns of *Flavobacterium columnare* from pond-cultured *Clarias gariepinus*. The incidence of multiple antimicrobial resistance of bacterial isolates have also been reported by other researchers such as Sultana *et al.* (2014), from their work on multi-antibiotics resistant bacteria in frozen food of animal origin sold in Dhaka, Bangladesh.

These multiple drug resistance could be as a result of indiscriminate use of antibiotics during fish production processes to prevent and eradicate bacterial diseases (Ogbonne *et al.*, 2018) or perhaps due to mutation (Syed *et al.*, 2012). The results obtained from this study shows that aquaculture environment can be a potential reservoir in the development and dissemination of antibiotics resistant bacteria. Though commensal bacteria do not cause diseases directly, they can transfer their resistance gene to other pathogenic organisms in the environment either by natural gene transformation or electroporation process (Wang *et al.*, 2006; Li and Wang, 2010). Luo *et al.* (2005) had also reported that inherited high frequency gene transfer mechanisms in commensal bacteria can expressively expedite antimicrobial resistance gene transfer. Thus, from various genetic background, different resistance mechanisms would likely emerged more from the commensal bacteria than their pathogenic counterpart (Wang, 2009). Zhang *et al.* (2011) have also reported that the gastrointestinal tract of bacteria host could serve as the incubator which intensify the antibiotics resistance gene transfer of a bacteria either in the presence or absence of selective pressure.

Multiple antibiotics resistance (MAR) index is an analytical measures or technique of analysis introduced in 1983 by Krumpnerman which helps to categorize or group different sources of high and low risk contamination of bacterial isolates based on their frequency of antibiotics resistance (Osundiya *et al.*, 2013). However, isolates with multiple antibiotics resistance index greater than 0.2 is considered to be from high risk source of contamination while bacterial isolates with multiple antibiotics resistance index less than 0.2 is an indicator of low risk contamination. Therefore, from this study, multiple antibiotics resistance index analysis revealed that it is only *Flavimonas oryzihabitans* that has 0.2 MAR index while other bacterial isolates from this work exhibited an MAR index range of 0.3 to 0.6 indicating high antibiotics usage and it is in total contradiction with the work of Kathleen *et al.* (2016) who reported low risk sources of contamination of multiple antibiotics resistance index from diverse bacterial isolated from Aquaculture in Borneo.

Conclusion: Indiscriminate use of drugs as growth promoter in fish farming have adversely contributed to the spread of antibiotics resistance and the best way to holistically provide solution to the menace of antibiotics resistance is to avoid the use of antibiotics in disease prevention rather vaccines, good nutrition and better farm management should be practiced.

References

- Abraham, T.J. (2011). Food safety hazards related to emerging antibiotic resistant bacteria in cultured freshwater fishes of Kolkata, India. *Advance Journal of Food Science and Technology* **3**: 69–72.
- Abu, G.O. and Wondikom, A.C. (2018). Isolation, Characterization and Antibiotic Resistance Profile Studies of Bacteria from an Excavated Pond in Port Harcourt Metropolis, Nigeria. *Journal of Applied Science and Environmental Management* **22**(8): 1177 – 1184.
- Ademola, O.O., Kovashnee, N., Balakrishna, P. (2009). Antibiotic resistance profiles of *Escherichia coli* isolates from river sources in Durban, South Africa. *World Journal of Microbiology and Biotechnology* **25**:1743–1749.
- Akond, M., Hassan, S.M.R., Saidul, A. and Momena, S. (2009). Antibiotics Resistance of *Escherichia coli* isolated from poultry and poultry environment of Bangladesh. *American Journal of Environmental Sciences* **11**(1):19-23.
- CLSI. (2016). Performance Standards for Antimicrobial Susceptibility Testing. Clinical and Laboratory Standards Institute, Wayne. Bauer, AW; Kirby, WMM; Strerris, JC; Turk, M (1999). Antibiotic susceptibility testing by standard single disk method. *American Journal of Clinical Pathology*. **45**: 493-496.
- Cockerill, F.R. (2012). Methods for Dilution Antimicrobial Susceptibility Tests for Bacteria That Grow Aerobically; Approved Standard—Ninth Edition. CLSI. p. 12.
- Donald, G.G., Jean, E.N. and Heather, A. (2013). A New twist to the Kirby-Bauer antibiotic susceptibility test activity: Increasing antibiotics sensitivity of *Pseudomonas fluorescens* through thermal stress. *Journal of Microbiology and Biology Education* **14**(2):269-270.

- Frieri, M., Kumar, K. and Boutin, A. (2017). Antibiotics resistance. *Journal of Infection and Public Health*10(4): 369 – 378.
- Gang, Z., Qing, S.S., Xiao, M.H., Xiao, B.X. (2015). The three bacterial lines of defence against of antimicrobial agents. *International Journal of Molecular Science*16(9):21711 – 21733.
- Gislene, G. F.N., Juliana, L., Paulo, C.F., Giuliana, L.S. (2000). Antibacterial activity of plant extracts and phytochemicals on antibiotics resistant bacteria. *Brazilian Journal of Microbiology*31:247-256.
- Kathleen, M. M., Samuel, L., Felecia, C., Reagan, E. L., Kasing, A., Lesley, M. and Toh, S. C. (2016). Antibiotic Resistance of Diverse Bacteria from Aquaculture in Borneo. *International Journal of Microbiology*2016: 1 – 9.
- Krumperman, P.H. (1983). Multiple antibiotic resistance indexing of *Escherichia coli* to identify high-risk sources of fecal contamination of foods. *Applied Environmental Microbiology*46(1): 165-170.
- Li, X. and Wang, H. H. (2010). Tetracycline resistance associated with commensal bacteria from representative ready-to-consume deli and restaurant foods. *Journal of Food Protection*73:1841–1848.
- Luo, H., Wan, K. and Wang, H. H. (2005). A high frequency conjugation system facilitated biofilm formation and pAmb1 transmission in *Lactococcus lactis*. *Applied Environmental Microbiology*71:2970–2978.
- Muhammad, I., Fiaz, A., Bushra, Y., Ayesha, R., Ayesha, I., Mohammad, A., Safdar, A.M., Iqra, M., Mohammad, Y., Qaisar, A., Mohammad, S.A.T., Ali, A., Sarfraz, A. (2020). Current trends of antimicrobials used in food animals and aquaculture. Oxford, London: Elsevier Inc, pp.50 – 55.
- Manyi-Loh, C., Mamphweli, S., Meyer, E. and Okoh, A. (2018). Antibiotic Use in Agriculture and Its Consequential Resistance in Environmental Sources: Potential Public Health Implications. *Molecules*23:795 – 843.
- Nyandjou, Y.M.C., Yakubu, S.E., Abdullahi, I.O., Machido, D.A. (2019). Multidrug Resistance Patterns and Multiple Antibiotic Resistance Index of *Salmonella* species Isolated from Waste Dumps in Zaria Metropolis, Nigeria. *Journal of Applied Science and Environmental Management*23(1): 41–46.
- Ogbonne, F.C., Osegbo, A.N., Nwokwu, C.P., Ukazu, E.R., Egbe, F.C., Akhiromen, D.I. and Aguta, O.J. (2019). Genotypic Characterization and Resistance Patterns of *Flavobacterium columnare* from Pond-cultured *Clarias gariepinus*. *Middle East Journal of Applied Science & Technology*2(1): 54 – 61.
- Ogbonne, F.C., Ukazu, E.R. and Egbe, F.C. (2018). Antibiotics Resistance Pattern and Plasmid Profiling of *Edwardsiella tarda* Isolated from *Heterobranchus longifilis*. *Journal of Biosciences and Medicines*6:95-105.
- Osundiya, O., Oladele, R. and Oduyebo, O. (2013). Multiple Antibiotics Resistance (MAR) indices of *Pseudomonas* and *Klebsiella* species isolates in Lagos University Teaching Hospital. *African Journal of Clinical and Experimental Microbiology*14(3): 164 – 168.
- Sethi, S., Kumar, R. and Gupta, S. (2013). Antibiotics production by microbes isolated from soil. *International Journal of Pharmaceutical Science and Research*4(8):2967-2973.
- Sultana, F., Afroz, K.H., Jahan, A., Fakruddin, M.D. and Datta, S. (2014). Multi-antibiotic resistant bacteria in frozen food (ready to cook food) of animal origin sold in Dhaka, Bangladesh. *Asian Pacific Journal of Tropical Biomedicine*4(1):268-271.
- Syed, Q.A.S., Duncan, J.C., Hamisi, L.N. and Henning, S. (2012). Prevalence of antibiotics resistance genes in the bacterial flora of integrated fish farming environments of Pakistan and Tanzania. *Environmental Science and Technology*46(16):8672-8679.
- Wang, H. H., M. Manuzon, M. Lehman, K. Wan, H. Luo, T. E. Wittum, A. Yousef, and L. O. Bakaletz. 2006. Food commensal microbes as a potentially important avenue in transmitting antibiotic resistance genes. *FEMS Microbiology Letter*254:226–231.
- Wang, H. H. (2009). Commensal bacteria, microbial ecosystems and horizontal gene transmission: adjusting our focus for strategic 300 YE ET AL. *J. Food Prot.*, Vol. 76, No. 2breakthroughs against antibiotic resistance, p. 267–281. In L.-A. Jaykus, H. H. Wang, and L. S. Schlesinger (ed.), *Foodborne microbes: shaping the host ecosystems*. ASM Press, Washington, DC.
- Zhang, L., Kinkelaar, D., Huang, Y., Li, Y., Li, X. and Wang, H. H. (2011). Acquired antibiotic resistance: are we born with it? *Applied Environmental Microbiology*77:7134–7141.

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Mycoflora Infestation On Smoked-Dried Fishes From Road Side Table Markets in Toru-Orua, Sagbama, Bayelsa State

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Abstract

Occurrence of mycoflora on smoke dried *Chrysichthys nigrodigitatus*, *Clarias gariepinus* and *Parachanna obscura*, obtained from roadside table marketers in Toru-Orua was studied. The fungal infestation was examined prior to the standard treatment of each fish species tissue to sterile media preparation (Potato Dextrose agar) isolation, serial dilution plating, incubation, counting isolator and inventory/identification. All fish species examined had signs of fungal infections which include *Mucor racemosus*, *Asperigillus fumigatus*, *Asperigillus niger*, *Asperigillus flavus* and *Penicillium arneffei*. The specimens *Parachanna obscura*, *Clarias gariepinus* had 3 fungal isolates, whereas the *Chrysichthys nigrodigitatus* has 2 fungal isolates and the rate of infestation ranged from $4 \times 10^3/\text{gm}$ (*A. niger*) to $10 \times 10^3/\text{gm}$ (*Mucor racemosus*) in the Northern Station, while in the Southern Station the range was $2.0 \times 10^3/\text{gm}$ (*A. flavus*) to $5.0 \times 10^3/\text{gm}$ (*A. fumigatus*). Mean percentage infection was, *Asperigillus* spp. 87.5%, *Mucor* spp. 37.5% and *penicillium arneffei* 37.5%. Also the northern Toru-Orua roadside table market had 5 fungi isolated during the studied, while the southern Toru-Orua roadside table market had 4 fungi isolated. When subjected to Student t-test analysis, the mean rates of infestation in the two location showed no significant difference at $P > 0.05$.

Keywords: Mycoflora, Rates of infestation, Smoke-dried fish, Road-side Table Market.

Introduction

Perishability is a common and important characteristic of fish and fishery products, which call for adequate preparations, preservation and processing to ensure wholesome products to consumers. A popular traditional method of keeping fishery product in wholesome condition is drying (Alfred-Ockiya, 1988; Alfred-Ockiya and Akeodi, 1998). However, smoked dried fishes are still invaded by rodents, insects and micro-organism such as fungi (Eyo, 2001). The occurrence of mycoflora as micro-organism in fish spoilage has been recognized earlier, especially the public health implications. (FAO, 2002; Okonta and Ekelemu, 2005; Bolaji, 2005; Bankole and Kpodo, 2005). Fafioye et al., (2002) identified various fungi in their study of smoked dried fishes in Ago-Iwoye, Ogun State, such as *Mucor* spp., *Asperigillus* spp., *Rhizopus* spp., and *Fusarium* spp. In fact, Bukola et al., (2008) investigated Mycoflora of smoked dried fishes sold in Akwalbom State and identified numerous mycoflora including *Asperigillus flavus*, *A. terreus*, *A. fumigatus*, *Absidia* spp. and *Penicillium* spp. with *A. terreus* occurring the highest. This study is therefore an attempt to investigate the occurrence of mycoflora on smoke dried fishes sold at roadside table marketing outlets in Toru-Orua, an emerging fast developing University in Bayelsa State.

Materials and Methods

The study was carried out at Toru-Orua Town, a community located along the Forcados River. The town is 13.6 Km from Sagbama Town, the Administrative Headquarters of Sagbama Local Government Area of Bayelsa State. Toru-Orua shares similar vegetation and climate conditions with other communities in Sagbama and Ekeremor LGAs which are under the West Senatorial District of Bayelsa State (Daukerei et al., 2020). The area is characterized by a tropical rain forest with rainfall occurring generally every month of the year and ranged 2000m-2500m and with short dry season. The temperature is high all-round the year with relatively constant high humidity within the range of 75-85% (Google Weather Forecast in September, 2021). The vegetation in the area is freshwater swamps and lowland rainforest. Enamored by the location of the River Forcados as a result of their ancestral fishing occupation, communities settlement pattern are mostly linear, paralleled along the river/coastal banks (Mnom and Akpi, 2014). Toru-Orua town lies between Latitude $5^{\circ} 05' 59''$ North and Longitude $6^{\circ} 03' 51''$ East. Based on a reconnaissance study, two major areas where table markets are prevalent were identified and designated as North and South locations of the town. Fishes for the study were selected based on their prevalence and selected fishes were *Chrysichthys nigrodigitatus*, *Clarias gariepinus* and *Parachanna obscura*.



Fig. 1: Point A (North Location) and Point B (South Location) of Roadsides Table Marketing
Source: Google Map

Smoke dried *Chrysichthys nigrodigitatus*, *Parachanna obscura* and *Clarias gariepinus* samples were purchased from roadside table marketing outlets in Toru-Orua, Sagbama Local Government Area of Bayelsa State and kept in polythene bags to the laboratory for study. In the laboratory, each fish sample was examined with a hand lens to ascertain that there are no micro-organisms growing on the external skin. Micro-organismal growth was promoted by aseptically cutting about ten grams portion of each fish tissue and macerated. Each macerated tissue was mixed with 90ml of peptone water and placed on a medium of Potato Dextrose Agar in which 250ml of Chloramphenicol as antibacterial agent was added. After thorough mixing, 1ml each of the sample solution was diluted and placed on petri dishes in duplicates. Thereafter, the petri dishes were incubated at 30°C for 7 days and observed regularly for fungal infestation.

After the incubation period, the whole medium on the petri-dish was observed with hand-held lens to note the arrangement of the spores. Then, a piece of the Mycelium was removed with a needle and mounted on a slide, stained, following Gram staining process, dried, and observed microscopically and fungi seen were identified to species level by using identification keys (Barley and Scott, 1970; Samson *et.al.*, 1981; Joseph, 1974). Data collected were analyzed using descriptive statistics and subjected to student t-test.

Results and Discussion

The identification of the isolated fungal organism was aided with the morphological characteristics shown in Table 1, especially, colour, size, and results of the Gram staining process. The colour observed were creamy white (*A. fumigatus*), white buffy (*M. racemosus*), brown black (*A. niger*) and grey fluffy (*Penicillium marneffe*). The sizes of the mycelium also vary from 3mm in *A. fumigatus*, *A. niger* to 1mm in *Penicillium marneffe*. These characteristics were similar to the colours and sizes of fungi isolated by Okonta and Ekelemu (2005) in their study, micro-organism in fish spoilage, Southern Nigeria. Similar characteristics were also observed during the study of traditional smoked dried freshwater fish in Ago-Iwoye, Ogun State, by Fafioye *et.al.* (2002). Also, the Gram staining process in this study gave Gram positive hypha for *A. fumigatus*, *Mucor racemosus* and Gram-positive mycelium in *P. marneffe*, whereas *A. niger* showed Gram positive rough wall conidia conidiophore.

Table 1: Morphological characteristics of fungal isolates, after Gram staining and identifying fungi

SN	COLOUR OF SPORE	APPROXI. SIZE OF SPORE	PRESENCE OF MYCELIIUM	GRAM STAINING POSITION (+VE & - VE)	FUNGI ISOLATED & IDENTIFIED
1	Creamy white	3mm	Yes	Positive hypha	<i>Aspergillus fumigatus</i>
2	White buffy	2mm	Yes	Positive hypha	<i>Mucor racemosus</i>
3	Brownish black	3mm	No conidiophore	Positive rough wallconidia	<i>Aspergillus niger</i>
3	Grey flubby	1mm	Yes	Positive mycellium	<i>Penicillium marneffe</i>

The fungal organisms isolated and identified from the three fish specimens and the number of organisms per gram of fish tissue from the two sampling stations (North and South) are shown in Table 2. The identified fungi were the storage fungi such as the *Aspergillus fumigatus*, *A. flavus*, *A. niger*, *Mucor racemosus* and *Penicillium marneffe*. These fungi are often known to be associated with area of high relative humidity which are above the critical value of 80-86% (Philips and Wallbridge, 1977; Eyo, 2001). Since Toru-Orua is located within the Niger Delta with a high relative humidity of 80-90% and within the critical relative humidity, it suggests that one primary cause of these fungi identified is high relative humidity which promotes the growth of fungi on smoke dried fishes.

Table 2: Summary of the fungal isolated and identified and the rate of infestation on smoked dried fishes in Toru-Orua, Bayelsa State.

S N	Scientific Name of Studied Fish	Common Name of Fish	Fungal Species Isolated and Identified	Stations Sampled in Toru-Orua Roadside Table Outlets	
				i. Northern Area Rate of Infestation	ii. Southern Area Rate of Infestation
1	<i>Chrysichthys nigrodigitatus</i>	Grey catfish	<i>Aspergillus fumigatus</i>	7.0x10 ³ /g	-----
			<i>Mucor racemosus</i>	5.0 x10 ³ /g	4.0 x10 ³ /g
2	<i>Parachanna obscura</i>	Snake-head	<i>Aspergillus fumigatus</i>	8.0 x10 ³ /g	5.0 x10 ³ /g
			<i>Mucor racemosus</i>	10.0 x10 ³ /g	-----
			<i>Penicillium marneffe</i>	4.0 x10 ³ /g	2.0 x10 ³ /g
3	<i>Clarias gariepinus</i>	Africa walking catfish	<i>Aspergillus niger</i>	4.0 x10 ³ /g	-----
			<i>A. flavus</i>	-----	2.0 x10 ³ /g
			<i>Penicillium marneffe</i>	9.0 x10 ³ /g	-----

The result in Table 2 revealed that fungi infestation on the smoked dried fishes studied were fish specific, for example, *Parachanna obscura* and *Clarias gariepinus* had three fungi species isolated and identified as *Aspergillus fumigatus*, *Mucor racemosus* and *Penicillium marneffe*, whereas, in *C. gariepinus*, *A. niger*, *A. flavus*

and *Penicillummarneffie* were isolated and identified. In fact, *Aspergillus spp.* were the most frequently occurring fungi in smoked dried fishes in Toru-Orua. This observation was also reported by Fafioye *et al.*, (2002) in their study of fungi infestation on five fresh water fish in Ago-Iwoye, Ogun State. In fact, they observed the prevalence of *Aspergillus spp.*, *Mucorspp.* and *Penicillum spp.* on most of the smoked dried fish sold in their study area. In terms of sampling stations, the Northern sampling station had more fungi infestation on smoke dried fishes with seven species, whereas the southern area had only four isolated and identified fungi organisms such as *Mucor racemosus*, *A. famigatus*, *Penicillummarneffie* and *A. falvus*. This observation may be explained as a result of the acid content of the different fish flesh. That is, various micro-organisms react differently in an acid medium. In fact, it is reported that moulds develop readily in an acidic medium and can thrive for long time (Eyo, 2001; De-Marindo, 1969; Fafioye *et al.*, 2002). The rate of infestation (Table 2) further showed that there is more infestation 10×10^3 organisms per gram of fish flesh in *Parachanna obscura* followed by *Clarias gariepinus*, 9×10^3 per gram of fish flesh in the Southern Toru-Orua area, the rate of infestation was 5×10^3 per gram of fish flesh in *Parachanna obscura* followed by *Chrysichthys nigroditatus* 4×10^3 and *Clarias gariepinus* 1×10^3 per gram. This observed could be due to the chemical composition of the various fish species studied as noted by Eyo (2001) that fish flesh chemical composition often influences the growth of fungi and mould.

The implications of the study results are that fungal and moulds infestation of smoke dried fishes in Toru-Orua could be due to the community's location with high relative humidity. Also, the practice of the mode of displaying fish for sale once removed from the smoking kiln. This exposes the fish that are not well dried into the environment which is very unhygienic coupled with the mode of storage. The polythene bags/sheets encourage warmth and prevent proper air circulation leading to sweating, then infestation of moulds, fungi and insects (Eyo, 2001; Fafioye *et al.*, 2002).

Conclusion and Recommendations

The findings of this study showed that fungal infestation is a common occurrence in smoke dried fish especially *Chrysichthys spp.*, *Parachanna obscura* and *Clarias gariepinus* very popular in Toru-Orua, Bayelsa State. These fishes and lot more are generally smoke dried and are commonly acceptable dried fish. Once dried fish are infested with fungal organisms, it is the end of the good quality of the fish. The fungi isolated and identified in this study gave an indication of the species that are most likely to cause spoilage of smoke dried fish during storage in Toru-Orua, Bayelsa State. However, more studies are needed to obtain a comprehensive checklist of all possible fungal on available fish species. This shall help provide ways of preventing their infestation so as to provide high-quality smoke-dried fish for the ever-increasing number of consumers in Toru-Orua, a rapidly expanding University community in Bayelsa State.

References

- Alfred-Ockiya, J. F. (1988). The Survey of Mycoflora Associated with some Smoke Dried Fishes in Rivers State. *Nigeria Journal of Biotechnology* Vol. 6. pp. 51-53
- Alfred-Ockiya, J. F., & Akeodi, J. (1998). Comparative study of fungal infestation of three traditionally smoke-dried freshwater fishes in Rivers State. *J Aqua Sci*, 13, 41-43.
- Bailey, W. R., & Scott, E. G. (1970). *Diagnostic Microbiology: A Textbook for the Isolation and Identification of Pathogenic Microorganisms*. CV Mosby.
- Bankole S.A., Kpodo R.A. (2005). Mycotoxin Contamination in Food Systems in West and Central Africa. In: *Reducing Impact of Mycotoxin in Tropical Agriculture with Emphasis on Health and Trade in Africa*, Accra, Ghana 13-16 September 2005.
- Bolaji, B. O. (2005). Performance Evaluation of a Simple Solar Dryer for Food Preservation. *Proceedings of 6th Annual Engineering Conference of School of Engineering and Engineering Technology, Federal University of Technology, Minna, Nigeria*.
- Bukola, C. A., Abiodun, A. O. and Ukpe, G. P. (2008). Mycoflora of Smoke Dried Fishes Sold in Uyo Eastern Nigeria. *World Journal of Agricultural Science*, 4(3): 346-350.
- Daukore, B. E., Yelwa, S. A., Akpu B. and Ajani, A. O. (2020). Geospatial Analysis of Crime Incidence in Bayelsa West Senatorial District, Bayelsa State, Nigeria. *Jalingo Journal of Social and Management Science*. Vol. 2(3): 1-22.
- De-Marindo, A. (1969). *Fish Curing and Processing*. MIR Publisher, Moscow, USSR. Pp 722
- Eyo, A. A. (2001). *Fish Processing Technology in the Tropics*. University of Ilorin Press, Nigeria. Pp 403
- Fafioye, O., Efuntoye, M. & Osho, (2002). A. Studies on the fungal infestation of five traditionally smoke-dried freshwater fish in Ago-Iwoye, Nigeria. *Mycopathologia* 154, 177–179

- Food and Agriculture Organization (2002). Report of Workshop on the Promotion of Sustainable Commercial Aquaculture in Zambia and Malawi: Lusaka, Zambia, 2-4 October 2002. FAO Fisheries Report N0. 733, FAO, Rome, Italy: pp1-46.
- Joseph, H. M. (1974). Taxonomy and Preservation of Fungus and Yeast Culture. Minoe Federal Ministry of Industries, Lagos. Pp 30
- Mmon, P. C. and Akpi, A. (2014). Spatial Analysis of Flood Vulnerability Levels in Sagbama Local Government Area Using Geographic Information Systems (GIS). *International Journal of Research in Environmental Studies* (IJRES) 1: 1-8.
- Okonta, A. A., and Ekelemu, J. K. (2005). A Preliminary Study of Micro-Organisms Associated with Fish Spoilage in Asaba Southern Nigeria. Proc. 20th Annual Conference of Fisheries Society of Nigeria. Port Harcourt. pp. 557-560.
- Philips, S., & Wallbridge, A. (1977). The mycoflora associated with dry tropical Fish in "Handling processing and Marketing of tropical fish" Tropical produces Institute.
- Samson RA, Hoestra ES, Van Oovshot CA. Introduction to foodborne fungi. Institute of the Royal Netherlands Academy of Arts and Science, 1981: 125 pp.

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Phenotypic Characterisation of *Listeria* Species in Pink Shrimps Sold In Lagos MetropolisAmusan, E. E.^{1*} and Sanni, A. I.²^{1*}Department of Fish Technology and Product Development, Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos²Department of Microbiology, University of Ibadan, Oyo State, Nigeria.**Abstract**

The present study was designed to determine the occurrence of *Listeria* species in raw and smoked shrimps. A total of 120 samples of raw and smoked shrimps were obtained randomly from five retail fish markets in Lagos metropolis. The samples were tested for the presence of *Listeria* species using the Oxoid *Listeria* Precis method, Oxoid *Listeria* test kit and MICROBACT *Listeria* 12L system. *Listeria* species was detected in 14 out of the 120 samples. *Listeria grayi*, *L. innocua* and *L. welshimeri* were detected in 3.3%, 3.3% and 10% of raw shrimps samples analysed respectively. The smoked shrimps recorded 5% and 1.67% of *L. grayi* and *L. monocytogenes* respectively. The consumption of these shrimps whether raw or undercooked may contribute to food-borne illness in Lagos metropolis and thus appropriate measures should be taken to prevent and control outbreaks that could arise from contamination associated with *Listeria* species.

Keywords: Occurrence, Retail Fish Markets, Consumption, Shrimp, Microbial load

Introduction

Shrimp are an important commodity in the international fisheries trade and there is an indication of an increase in worldwide consumption of this crustacean. *Listeria* have been isolated from shrimps and shrimp products on a regular basis since the 1980s. The continued reporting of the presence of these pathogens in fresh and frozen shrimps, and even in the lightly preserved and ready-to-eat products, indicates that the existing practices used by the manufacturers or processors are insufficient to eliminate these pathogens (Wan Norhana *et al.*, 2010). *Listeria* species especially *Listeria monocytogenes* remains a health risk for consumers. Although control measures implemented during recent decades have reduced the prevalence of this bacterium in many food categories, the number of illnesses reported over the years has not decreased (EFSA, 2017). This organism occurs widely in agricultural, aquaculture, and the food industry (Buchanan *et al.*, 2017). Listeriosis caused by eating food contaminated with *Listeria monocytogenes* results in increased hospitalization rates than any other zoonosis in the European Union (almost 99% of the cases), and in the highest fatality rate (close to 20%) (EFSA, 2017). There is a dearth of information on this pathogen in Nigeria. Thus, this study was designed to determine the occurrence of *Listeria* species in shrimps in Lagos metropolis.

Materials and Methods**Sample Collection**

One hundred and twenty samples comprising of 60 raw and 60 smoked pink shrimps were randomly bought from Badagry, Iyana-Ipaja, Liverpool, Makoko and Mushin markets. Sampling was carried out monthly for one year. The samples were collected in separate sterile polythene bags, labeled and transferred to the Microbiology laboratory at the Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos. These samples were analysed aseptically for the presence of *Listeria* species.

Phenotypic Characterisation of *Listeria* species

The isolation of *Listeria* was carried out using the Oxoid *Listeria* Précis method. For each sample, 25 g was added to 225 ml of Oxoid Novel Enrichment (ONE) broth and stomached for 30 seconds to mix the sample. It was incubated at 30 °C for 24 hours. After 24 h enrichment, the broth cultures were agitated and a loopful was inoculated onto Brilliance *Listeria* agar. This was incubated appropriately (37 °C for 24 – 48 h). The plates were examined for blue-green colonies with or without opaque white halos; at least 3 suspected colonies were subcultured on Tryptone Soya Agar (TSA, Oxoid) and incubated at 37 °C for 24 h. Phenotypic characterization such as Gram's staining, Catalase and motility tests were carried out according to the methods of Hitchins and Jinneman, (2011). The Oxoid *Listeria* Latex Agglutination Test and MICROBACT *Listeria* 12L system were also used for phenotypic characterisation.

Results

Tables 1&2 give a breakdown of the number of raw and smoked shrimps tested and the number of positive samples. A total of 10 samples (16.6%) were positive for *Listeria* spp. out of 60 raw samples tested. Similarly, 4 samples (6.67%) were positive for *Listeria* spp. from the 60 smoked samples that were analysed. In total, out of the 120 samples tested, 14 samples (11.6%) were positive for *Listeria* spp. (Table 3).

Table 1: Occurrence (%) of *Listeria* species in Raw Shrimps

Markets	Number of samples analysed	<i>Listeria</i> spp. Positive n (%)	<i>Listeria grayi</i> n (%)	<i>L. innocua</i> n (%)	<i>L. welshimeri</i> n (%)
Badagry	12	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Iyana Ipaja	12	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Liverpool	12	3(25.0)	0 (0.0)	0 (0.0)	3(25.0)
Makoko	12	3(25.0)	0 (0.0)	0 (0.0)	3(25.0)
Mushin	12	4(33.3)	2(16.6)	2(16.7)	0(0.0)
Total	60	10(16.6)	2(3.3)	2(3.3)	6(10.0)

n = number

% = percentage

Table 2: Occurrence (%) of *Listeria* species in Smoked Shrimps

Markets	Number of samples analysed	<i>Listeria</i> spp. Positive n (%)	<i>Listeria grayi</i> n (%)	<i>L. monocytogenes</i> n (%)
Badagry	12	0 (0.0)	0 (0.0)	0 (0.0)
Iyana Ipaja	12	0 (0.0)	0 (0.0)	0 (0.0)
Liverpool	12	2(16.7)	1(8.3)	1 (8.3)
Makoko	12	2(16.7)	2(16.7)	0 (0.0)
Mushin	12	0 (0.0)	0 (0.0)	0 (0.0)
Total	60	4(6.67)	3(5.0)	1(1.67)

n = number

% = percentage

Table 3: Occurrence (%) of *Listeria* species in Shrimps

Samples	Number of samples analysed	<i>Listeria</i> spp. Positive n (%)	<i>Listeria grayi</i> n (%)	<i>L. monocytogenes</i> n (%)	<i>L. innocua</i> n (%)	<i>L. welshimeri</i> n (%)
Raw Shrimps	60	10(16.6)	2 (3.3)	0 (0.0)	2(3.3)	6(10.0)
Smoked Shrimps	60	4(6.6)	3(5.0)	1(1.6)	0 (0.0)	0 (0.0)
Total	120	14(11.6)	5(4.2)	1(0.8)	2(1.6)	6(5.0)

n = number

% = percentage

Discussion

Listeria spp. are indigenous to the marine and estuarine environments (Reilly and Kaferstein, 1997) and their association with shrimp is therefore to be expected. The occurrence of *Listeria* spp. in shrimp is similar to the observation of Rahimi *et al.* (2012) and Mashak *et al.* (2021) who recorded an occurrence rate of 11.7% and 12% respectively from shrimps. Higher prevalence of 40%, 25% and 36% for *Listeria* spp. in seafoods were recorded by these authors (Ikeh *et al.*, 2010; Amusan, 2012; Rezaei *et al.*, 2018). Tirloni *et al.* (2021) reported that 3.8% of ready-to-eat shrimps were contaminated with *Listeria* species. The presence of *Listeria* spp. in smoked seafood was reported by Chukwu *et al.*, 2006; Salihu *et al.*, 2008 and Adeyeye *et al.*, 2015. The presence of *Listeria* spp. is directly associated with the implementation of adequate hygiene practices used by the producers of foods in the different countries (Bustamante *et al.*, 2020). The variation in the results in different studies is related to differences in the rate of seafood contamination, isolation and identification methodologies (Menon *et al.*, 2021). The primary

source of *Listeria* contamination is generally measured to be raw fish and seafood material. Because *Listeria* is generally originated in coastal waters and lake surface waters, seafood captured or cultivated in these waters may harbour the bacterium. Nevertheless, seafood that are purchased in bulk and repackaged before sale may be vulnerable to *Listeria* contamination (Mashak et al., 2021). The isolation of *L. monocytogenes* in smoked shrimp suggest that there is a risk of acquiring listeriosis through shrimps. Considering outbreaks of listeriosis associated with different foods, avoidance of consumption of insufficiently cooked shrimps by at-risk populations is recommended (Rahimi et al., 2012).

Conclusion

The consumption of these shrimps whether raw or undercooked may contribute to food-borne illness in Lagos metropolis and thus appropriate measures should be taken to prevent and control outbreaks that could arise from contamination associated with *Listeria* species.

References

- Adeyeye, S.A.O., Oyewole, O.B., Obadina, A.O., Omemu, A.M., Adeniran, O.E., Oyedele, H.A. and Abayomi, S.O. (2015). Quality and Safety Assessment of Traditional Smoked Fish from Lagos State, Nigeria. *International Journal of Aquaculture*. 5(15):1-9.
- Amusan, E.E. (2012). Detection of *Listeria monocytogenes* in frozen fish in Lagos, Nigeria, Proceedings of the 27th Annual Conference and Biennial General Meeting of the Fisheries Society of Nigeria held at Banquet Hall Government House/Faculty of Law, Niger-Delta University, Bayelsa State, 25th-30th November, pp. 307-310.
- Buchanan, R.L., Gorris, L.G.M., Hayman, M.M., Jackson, T.C. and Whiting, R.C. (2017). A review of *Listeria monocytogenes*: an update on outbreaks, virulence, dose-response, ecology and risk assessments. *Food Control*. 75: 1–13.
- Bustamante, F., Maury-Sintjago, E., Cerda Leal, F., Acuña, S., Aguirre, J., Troncoso, M., Figueroa, G. and Parra-Flores, J. (2020). Presence of *Listeria monocytogenes* in Ready-to-Eat Artisanal Chilean Foods. *Microorganisms* 8:1669; doi: 10.3390/microorganisms8111669.
- Chukwu, O.O.C., Ehizibolo, O.D., Mustapha, A.I., Chukwu, D.I., Olabode, O.A. and Ogbonna, C.I.C. (2006). *Listeria* species in Smoked Fish on the Retail Markets of Jos, Nigeria. *Animal Production Research Advances*. 2(4): 231-234.
- Ikeh, M. A. C., Obi, S. K. C., Ezeasor, D. N., Ezeonu, I. M. and Moneke, A. N. (2010). Incidence and pathogenicity profile of *Listeria* sp. isolated from food and environmental samples in Nsukka, Nigeria. *African Journal of Biotechnology*. 9(30): 4776-4782.
- Mashak, Z., Banisharif, F., Banisharif, G., Pourian, M.R., Eskandari, S., Seif, A. Dehkordi, F.S. and Alavi, I. (2021). Prevalence of *Listeria* Species and Serotyping of *Listeria monocytogenes* Bacteria Isolated from Seafood Samples. *Egyptian Journal of Veterinary Sciences*. 52(1): 1-9.
- Menon, K.V., Sunil, B. and Latha, C. 2021. Prevalence and antibiotic resistance profile of *Listeria* spp. associated with seafoods from fish catchment areas in Kerala, India. *Veterinary World*. 14(3): 777-783.
- Rahimi, E., Shakerian, A. and Raissy, M. (2012). Prevalence of *Listeria* species in fresh and frozen fish and shrimp in Iran. *Annals of Microbiology*. 62: 37–40.
- Reilly A. and Kaferstein F. (1997). Food safety hazards and the application of the principles of hazard analysis and critical control point (HACCP) system for their control in aquaculture production. *Aquaculture Research*. 28: 735–752.
- Rezai, R., Elham, A. and Behnam, S. (2018). Prevalence and Antimicrobial Resistance Profile of *Listeria* Species isolated from Farmed and On-Sale Rainbow Trout (*Oncorhynchus mykiss*) in Western Iran. *Journal of Food Protection*. 81(6): 886-891.
- Salihu, M.D., Junaidu, A.U., Manga, S.B., Gulumbe, M.L., Magaji, A.A., Ahmed, A., Adamu, A.Y., Shittu, A. and Balarabe, I. (2008). Occurrence of *Listeria monocytogenes* in smoked fish in Sokoto, Nigeria. *African Journal of Biotechnology*. 7: 3082-3084.
- Tirloni, E., Nauta, M., Vasconi, M., Di Pietro, V., Bernardi, C. and Stella, S. (2020). Growth of *Listeria monocytogenes* in ready-to-eat “shrimp cocktail”: Risk assessment and possible preventive interventions. *International Journal of Food Microbiology*. 334: 108800 <https://doi.org/10.1016/j.ijfoodmicro.2020.108800>.
- Wan Norhana, M.N., Poole, S.E., Deeth, H.C. and Dykes, G.A. (2010). Prevalence, persistence and control of *Salmonella* and *Listeria* in shrimp and shrimp products: A review. *Food Control*. 21: 343–361.

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The Effect of *Adhatoda bucculzii* Plant Extract on the Fungal Load of *Periophthalmus Barbarus*

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Abstract

In the present study, One hundred and fifty live adult *Periophthalmus barbarus* with mean weight of $20.0g \pm 0.22g$ and length $18.4 \pm 0.00cm$ were exposed to five concentrations: 0.00 mg/ml, 8.35×10^{-4} mg/ml, 1.67×10^{-3} mg/ml, 2.51×10^{-3} mg/ml and 3.34×10^{-3} mg/ml of *Adhatoda bucculzii* plant extracts for 96 hours. Analysis for fungal populations/isolates were conducted for fresh (0hrs, 3hrs, 6hrs, 9hrs and 12 hours) and dry (week 0, week 2, week 4, and week 6). The results revealed that total fungi count (TF log₁₀cfu/g) in 0hr, 3hr, 6hr, 9hr and 12hr were far less than 5.7×10^6 cfu/g standard acceptable limit. The TF for the dry samples also did not rise above the acceptable limit. Nevertheless, some mycotoxin producing isolates such as *Aspergillus spp*, *Fusarium spp*, and *Penicillium spp* were detected, which portends public health dangers for the consuming human population. It was observed that increased concentration of *Adhatoda bucculzii* plant extracts at T5 led to decreased population of fungi (from 67.0 ± 6.25 in T1 0hr ($0.00mg/ml$) – 78 ± 6.25 in T1 12hrs to 2.0 ± 1.00 in T5 0hr – 44.0 ± 4.58 in T5 12hr for fresh samples). Fungal populations were absent in the first 2 weeks only to reappear in weeks 4 and 6 as moisture increased.

Keywords: Fungal load, Mudskippers, Plant extracts, Fish disease.

Introduction

In Nigeria the cost of buying fish food is cheaper when compared to the costs of beef, mutton pork, and veal poultry etc. It is a preferred source of the much needed animal protein with high acceptability and little or no religious bias, which give it an advantage over pork or beef (Adeyemi, *et al.*, 2014). Fish is a suitable medium for growth of micro-organisms if poorly processed. The growth of micro-organisms and other non-microbial activities such as lipid oxidation contribute to the deterioration of fish products (Jimoh *et al.*, 2014). It then means that factors that lead to the deterioration of fish include microbial load, autolysis oxidation and hydrolysis of fats. According to Ayolabi *et al.*, 2010, fish is a highly perishable product due to its high susceptibility to autolysis, oxidation and hydrosis of fats and microbial spoilage. Fisher folks must therefore be careful in the handling processing and preservation of fish for consumption by man.

The environment where a fish is caught goes a long way in determining the population of micro-organism found in the fish. The microbial flora of caught fish and other aquatic specimens, according to Ayolabi *et al.*, 2010, is a reflection of the microbial quality of the water where they are harvested. They also stated that in most cases, fresh fish flora are mainly bacteria, fungi are absolutely absent in fresh fish except a few yeast which have been shown to play no role in spoilage. (this is true because fungi are notable saprophytes and can only grow or thrive on dead and decomposing organisms. Junaid *et al.*, 2010 in their own view, reported that fungi are omnipresent in the environment, being found wherever water, suitable organic nutrients and an appropriate temperature occur. They also stated that many different fungal species can spoil food product or produce mycotoxins or both. In Nigeria according to Junaid *et al.* (2010), fish is eaten fresh preserved or processed. Fish though a perishable food begins to spoil as soon as it is caught perhaps even before it is taken out of the water. Spoilage proceeds as a series of complex enzymatic, bacterial and chemical changes that begin as soon as the fish dies. The present study evaluates the fungi isolates in *P. barbarus* caught with an ichthyotoxic plant-*A. bucculzii* putting into consideration the role they play in public health.

Materials and Method

One hundred and fifty live adult *P. barbarus* were procured from fishermen in Ogbogoro station of the New Calabar River, moved to the laboratory of NIOMR/ARAC in Buguma. The fish were acclimated for seven days prior to the commencement of the experiment in a netted happa with a mud at the bottom and floating materials which provide a resting terrestrial platform for the fish. The fish were fed with pieces of crabs. They were fed two times daily (9am

and 4pm). Ten fish were placed in each of the fifteen aquarium tanks for the experiment. One aquarium served as control with only water, while the remaining four were treated with the plant extract and this was Triplicated, the plant extract was obtained by adding 3.0 litre of water to 0.5kg of mashed plant. 0.0ml, 0.1ml, 0.2ml, 0.3ml and 0.4ml representing 0.0mg/ml, 8.35×10^{-4} mg/ml, 1.67×10^{-3} mg/ml, 2.51×10^{-3} mg/ml and 3.34×10^{-3} mg/ml respectively.

Water Quality Maintenance

Water quality parameters were monitored before introduction of the experimental organisms into the aquarium tanks. The parameters that were measured are temperature, salinity, hydrogen ion concentration (pH) and dissolved Oxygen (DOs). This was done to make sure that the water quality standards are maintained. Water temperature was taken by using mercury in glass thermometer, and the hydrogen ion concentration (pH) by pH meter (Mettler 340). Dissolved Oxygen Concentration was determined using an Oxygen meter (Oxyguard Handy MK II type) and their means calculated.

Total Fungi Count

Potato dextrose agar (PDA) was used to carry out the analysis in the present study. The medium was prepared according to manufacturers direction by dissolving 39g/l, sterilized by autoclaving at 121°C for 15 mins allowed to cool for about 45°C, treated with lactic acid (0.1%) poured into sterile petridishes and allowed to solidify. After serial dilution exactly 0.1ml aliquote of inoculum was aseptically inoculated on plate using spread plates techniques. Plates were incubated at ambient temperature for 5-7days, there after colonies were counted sub-cultured on freshly prepared PDA medium. Each different colony was viewed/examined under the microscope. Cultural characteristics and microscopic/morphological appearance were used to identify fungal isolate.

Statistical Analysis of Data

At the end of the experiment, means and standard deviations of collected data were analyzed using SPSS statistical programme.

Results

From Table 1 it was observed that increased concentration at T5 (3.34×10^{-3} mg/ml) led to decreased population of fungi (from 67.0 ± 6.25 in T1 0hr ($0.00 \text{ mg/l} - 78 \pm 6.25$ in T1 12hrs) to 2.0 ± 1.00 in T5 (3.34×10^{-3} mg/ml) 0hr –

Treatment	T1	T2	T3	T4	T5
Hours					
0hr	67.0 ± 6.25	33.3 ± 5.77	32.0 ± 1.00	24.0 ± 1.00	2.0 ± 1.00
3hr	76.0 ± 1.00	36.0 ± 5.29	35.0 ± 5.00	23.0 ± 4.36	18.0 ± 2.00
6hr	89.0 ± 9.54	82.0 ± 7.21	39.0 ± 8.54	13.0 ± 2.65	23.0 ± 8.19
9hr	58.0 ± 6.25	56.0 ± 7.21	48.0 ± 13.9	16.0 ± 3.46	25.0 ± 4.58
12hr	78.0 ± 6.25	77.0 ± 7.00	180 ± 14.7	114 ± 5.57	44.0 ± 4.58

44.0 ± 4.58 in T5 12hr for fresh samples). In Table 2, it was observed that fungal growth resumed in week 4 and week 6.

Table 1: Means And Standard Deviations Of Data From Fresh Samples

Table 2: Means And Standard Deviations Of Data From Dry Samples

Treatment	T1	T2	T3	T4	T5
Weeks					
0	Nil	Nil	Nil	Nil	Nil
2	Nil	Nil	Nil	Nil	Nil
4	42.0 ± 9.17	41.0 ± 8.33	20.0 ± 9.58	32.0 ± 5.57	21 ± 2.64
6	76.0 ± 4.58	75.0 ± 5.00	114 ± 9.64	48.0 ± 7.00	230 ± 17.78

Discussion

The microbial loads on the fish recorded in this study fall within the maximum recommended microbial counts for good quality fish produce i.e 5×10^5 ($5.7 \log_{10}$ cfu/g) that fish with microbial load of less than 10^6 cfu/g is acceptable from the microbiological point of view (Ayeloja *et al.*, 2011). The above finding is in agreement with Ayeloja *et al.*, 2011 who reported that *C. gariepinus* smoked at 12 hours was still good up to 12 hours after slaughter prior to smoking. A source of worry is the presence of pathogenic fungi as isolated such fungi have been incriminated as the causes of most human & veterinary disease known to man, thereby inducing serious threats to public health. Majority of the isolates belonging to *Aspergillus Sp.* Are potential aflatoxin producers. According to Salawudeen *et al.*, 2017, fungal mycotoxins produce a wide range of injurious effects in animals. In addition to causing food borne hazards to human. According to them, these mycotoxins may result to decreased productivity immune suppression and chronic damage to vital tissues and organs of animals and humans Mahmud *et al.*, 2018, reported that most mycotoxins are stable compound, that are not destroyed during food processing or home cooking and several cases of human gastroenteritis, severe diarrhea and food poisoning outbreaks have been recorded. Mahmud *et al.*, 2018 reported that the presence of mycotoxin producing fungi (*Aspergillus spp*, *Fusarium spp*, and *penicillium spp*) in captured fish indicated the degree of habitat and handlers contamination.

Kulkarni & Aggarwal, (2006) reported that *Trichophyton interdigitale* cause vesicular and preseptal cellulitis. Preseptal cellulitis according to them, typically affects children and is usually secondary to infections around the face and cranium. *Aspergillus Sp.* according to Salawudeen *et al.*, 2017, have been documented to be associated with the disease outbreak in fish culture. According to them, *Aniger* is a human pathogen and environmental contaminant and *A. fumigatus* has been identified as important agents of nosocomial fungal infections and implicated as being responsible for life-threatening pulmonary disease of animal and immune- compromised human in the world. *A. flavus* and *A. parasiticus* predisposes fish to aflatoxin contamination and consumers to aflatoxicosis if the fish are consumed by man. It was observed that fungal growth resumed in week 4 and week 6. This may be due to increase in water activity and moisture content, which is in agreement with Gandotra *et al.*, (2012) who reported that products deteriorates by growth of mould if the water content is approximately 15%. The rapid reduction in water activity $a_w = 0.75$ is the most important factor in controlling (fungi) mould contamination of fishery products during storage (Kolakowaska, 2002, Kumar *et al.*, (2013).

Conclusion and Recommendation

The study investigated the effect of *A. bucculzii* extract on the fungal load of *P. barbarus*. Seven fungal isolates were identified. Identification of the fungi was based on morphologies and with the help of authentic manuals of fungi. The most common isolates were. *Aspergillus spp*, *Mucor spp*, *Saccharomyces spp*, *Fusarium*, *Penicillium spp*, *Trichophyton spp* and *Cladosporium spp*. Potential aflatoxin producing species of fungi were isolated. Isolated fungi may be part of the fish environment or due to poor handling or preservation. Periodic examination of fish with respect to its immediate aquatic environment should be conducted to ensure that they are devoid of fungi contamination to conserve public health. Aflatoxin level in fish should be quantified to ensure they are not above limit allowable for human consumption.

References

- Adeyemi, J.W., Sodamola, M.O., Ayeloja, A.A Oladele-Bukola and Shittu, M.O (2014). The influence of replacing maize with *Chrysophyllum albidum* seed meal on Growth Response and Nutrient utilization in *Clarias Gariepinus*. *AgroSearch* 14(1):54-61.
- Ayeloja, A.A., George, F.O.A, Obasa, S.O and Sarni, L.O (2011). Effect of post-slaughter Time intervals on the Quality of the African Catfish *Clarias gariepinus* (Burchell, 1822). *African Journal of Food Technology* Volume 6/issue 9/page No: 790-797.
- Ayolabi, E.A; Atakpo, E.A; Adeoti, L: Otorbor, E.C and Arerin, T (2010). Groundnut Quality Assessment using predrilling Electrical Measurements. *Journal of Environmentla hydrology* vol. 17. Pp 1-12.
- Gandotra, R.; Meenakshi, K., Sweta, G. and Shallini, S. (2012). Changes in proximate composition and microbial count by low Temperature preservation in Fish Muscle of *Labeo rohita* (Ham-Buch) 10SR *J. Pharm. Biol.Sci* 2(1): 13-17.
- Junaid, S.A.; Olabode, A.O.; Onwuliri, F.C., Okwori, A.E and Agina, S.E (2006). The antimicrobial properties of *ocimum gratissimum* extracts on some selected bacterial gastrointestinal isolates. *Afr. J.Biotechnol.*, 5:2315-2321.
- Kolakowska, A (2002). Lipid oxidation in food systems. In Z. Sikorski & A. Kolakowska (Eds). *Chemical and functional properties of food lipids*. London, UK: CRC Press. Pp 133-165.

- Kulkarni, A.R and Aggarwal, S.P (2006). Preseptal cellulitis: an unusual presentation of *Trichophytoninterdigitale* in an adult. *Eye* 20, 381-382.
- Kumar, A., Singh, P.J and Danish, Mohd (2013) changes in proximate, biochemical and microbiological characteristics of dried labeogonius fillets during storage at room temperature. *African Journal of Biotechnology* 12(20): 2997-3005.
- Mahmud, A.Z., Abraha, B., Samuel, M., MohammedIdris H., Abraham, W and Mahmud, E. (2018). Fish preserving: A multi-dimensional approach. *MOJ Food Process Technol.* 6,303-310.
- Salawudeen, M.T., Kazeem, H.M., Raji, M.A., Oniye, S.J., Kwanashie, C.N and Ibrahim, M.J (2017). Isolation and identification of fungi from apparently healthy and diseased *Clarias gariepinus* from freshwater in Zaria, Kaduna State, Nigeria. *Microbiology Research International* 5 (1), 8-15.

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Isolation and Biochemical Characterization of Important Fish Pathogens from River Niger and Other Major Rivers in Anambra State

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Abstract

This study is designed to isolate and biochemically characterize the pathogenic bacteria of fish from Niger River, Otuocha river and Amansea river. Thirty two fishes (16 tilapia and 16 catfish) were sampled from Niger River, Otuocha River and Amansea River. The intestines (one gram) of all the fish samples from these rivers were subjected to screening (cultured) for the presence of pathogenic microbes of green colonies using *Aeromonas* agar base(Sigma) enriched with Ampicillin to make the media more selective. Blood agar was used for haemolysis test and Microscope was used to determine their morphological characteristics. Microscopic analysis result showed that all the isolates were rod shaped and motile. Biochemical characterization of the pure isolates were carried out by appropriate qualitative tests involving lysine, arginine and ornithine tests which are confirmatory tests for the presence of *Enterobacteriaceae* family. The results showed that, of all the fish samples screened (cultured), only the catfish from Niger river, Otuocha river and Amansea river showed pure colonies with green colour on the *Aeromonas* agar base selective media while no growth was observed on the tilapia samples. Blood agar haemolysis analysis showed negative for all the isolates hence not haemolytic. Biochemical analysis indicated that they were gram negative rods, motile, oxidase positive, catalase positive, urease positive, can utilize citrate, hydrogen sulphide positive, and positive to lysine, arginine, and ornithine and can ferment glucose. The study has shown that fish (mostly catfish) sampled from some rivers in Anambra state contained, as at the period of sampling, more than one pathogenic microorganism (*Citrobacterfreundii*, *Enterobacter cloacae*, *Serratia rubidaea* and *Ochrobactrum anthropi* bacteria).

Keywords: Fish Pathogens, Isolation, Biochemical characterization, Blood agar, River Niger

Introduction

In Nigeria and especially in Southern part, fish and fishery products are major food products necessary to attain protein requirements. However, these food products are often contaminated by various food pathogens like *Enterobacteriaceae* family, a large number of genera that are biochemically and genetically related to one another. Many of the traditional or familiar bacteria are found in this family such as *Escherichia*, *Shigella*, *Salmonella*, *Enterobacter*, *Proteus*, *Yersinia* (Williams *et al.*, 2010) and (MacFaddin *et al.*, 1980). The ontology and scientific classification of these pathogens have been carried out in different studies (Holmes *et al.*, 1988 and De Ley, 1992). *Ochrobactrum anthropi* strains have been isolated from samples, including human blood and fish, originating from different continents (Holmes *et al.*, 1988, Velasco *et al.*, 1998). *Citrobacter freundii*, member of the family *Enterobacteriaceae*, is a significant opportunistic infections and has been associated with neonatal meningitis and brain abscess. (Julie *et al.*, 1999, Alfredo *et al.*, 1987 and Fraser *et al.*, 2007). *Enterobacteriaceae* were found in high numbers after storage at 78 degree centigrade in 6% of consumers packs of pasteurised milk or cream, in 31% of retail fish and in 100% of retail packs of minced meat (Lindberg *et al.*, 1998) and *Serratia* species isolates from Fish (Yu *et al.*, 2004). Fish pathogens like *Enterobacteriaceae spp.* are predisposing factor to the development of septicemia and abortion in horses, cattle, goats and pigs. Pneumonia, wound infections and cases of diarrhea in adult humans and new born babies.

Enterobacteriaceae strains, *Ochrobactrum anthropi* have been ranked the greatest risk factors contributing to the prevalence and severity of diseases and infections of the fish pathogen on man, and the consequences are accrued to the consumption of the infected fish foods. Do Nigerian rivers really infected with these bacteria? This will create awareness since greater percentage of the people depend on fish for protein, find the accurate approach of identifying them so as to enable affected person(s) seek for medical help without delay. In this present research,

detection of pathogenic *Enterobacteriaceae* spp. and *Ochrobacterium anthropi*; their characterization have assumed prime importance, it would therefore be necessary to conduct accurate detection of these pathogens and characterize the isolates. The aim is to biochemically characterize pathogenic bacteria of fish in some major rivers in Anambra State.

Methods

The study was carried out in Awka, Anambra State for six months (January to June).

Sample (Fish) Procurement/Collection

The fish samples used were purchased from fisher men at River Niger, Amansea and Otuocho River in Anambra State. They were carried to the laboratory in a sterile container where they were sterilized with ethanol before use. A total of thirty two (32) fish samples were used, eight tilapia and eight cat fish from River Niger and eight (four tilapia and four cat fish) fish samples each from Amansea and Otuocho rivers and samples used were taken from the intestinal track of the fish samples.

Sampling

Total of thirty two (32) fishes (sixteen and sixteen catfish) were sampled from the following rivers: Niger River, Otuocho River and Amansea River.

Screening For Pathogenic Microbes of Green Colonies

The thirty four (32) fish samples (sixteen tilapia and sixteen catfish) that were sampled from the rivers were subjected to screening for the presences of the pathogenic microbes of green using *Aeromonas* agar base selective media (Sigma Andrich) Ampicillin antibiotics was added appropriately to the media to make it more selective.

Sample Processing and Stock Culture Preparation

The fish samples were dissected using a surgical razor blade, subsequently, samples were taken from the intestinal tract of the tilapia fish and cat fish samples respectively. Samples of one gram (1g) each were weighed, pulverized in sterile mortar and pestle and transferred into 8 test tubes. 4ml of alkaline peptone water was added into each sample in a test tube and incubated at 37°C for 24h to get stock solution.

Serial Dilution Preparation

Exactly 10^{-3} Serial dilution of the stock solution was prepared for each sample and the maximum dilution was used in the plating on the *Aeromonas* Agar base media.

Procedure:

0.9ml of distilled water was transferred into 3 (autoclaved) test tubes and 0.1ml of stock culture was transferred to the first test tube; 0.1ml is transferred from the first test tube to the second test tube and down to the third test tube.

Plating and Evaluation of the Suspected Colonies

A 0.1ml aliquot was aseptically transferred from the third diluted test tube (10^{-3}) of each sample unto sterile petri dishes containing *Aeromonas* agar base using spread plate method. The plates were incubated at 37°C for 24hrs. The culture were observed for Green colonies. The green colonies were lightly covered with yellow colonies in less than twenty- four hours of incubation which was later changed to green colonies after twenty-four hours of incubation at 37°C.

Pure Culture Preparations from the Mixed Culture

Wire loop was (after heating to red hot and cooled) used to sub-culture the green colonies on nutrient agar using streak plate method and later sub-cultured back on the *Aeromonas* agar base selective media.

Blood Agar Hemolysis Test

Haemolysis of the pure isolates was determined by streaking the isolates from the three rivers on a blood agar plate. After incubation overnight, the medium was inspected for the signs of alpha- or beta-haemolysis.

Microscopic Analysis

A smear of the pure isolates were prepared and examined under light microscope

Biochemical Identification and Characterization of the Isolates

Grams Staining, Citrate Utilization, Motility and Hydrogen Sulfide, Catalase, Oxidase, Urease, Glucose Fermentation, Ornithine, Lysine and Arginine test were carried out following the method of Gram (Macfaddin and Jean 1980, MacFaddin *et al.*, 2000 and Sarkar *et al.*, 2013).

Results

Media Isolation

All the Isolates from River Niger, Amansea and Otuocha river produced green colonies and resistant to ampicillin. (Plate 1).



Plate 1: Pure culture Image of the isolates after 24 hours.

Microscopic Analysis:

Microscopic analysis result showed that all the isolates were rod shaped and motile.

Blood Agar Haemolysis Test

Blood agar haemolysis analysis showed negative as all the isolates from the three rivers did not show any haemolytic activity.

(Plate 2).



Plate 2: Pure culture Image in blood agar

Biochemical Characterization of Pure Isolates

The result of the biochemical tests of pure isolates showed that the isolates were gram negative, motile, oxidase positive, catalase positive, urease positive, citrate positive, hydrogen sulphide positive, and positive to lysine, arginine, and ornithine can ferment glucose (Table 1).

Table 1: Physiological and Biochemical Characteristics of the Pure Isolates.

Tests	SAMP.1	SAMP.2	SAMP.3	SAMP.4	MICROBES
Gram staining	-	-	-	-	<i>Serratiasp</i> , <i>Ochrobacteriumsp</i> , <i>Citrobactersp</i> , and <i>Enterobacteriaceae spp</i> .
Citrate utilization	+	+	+	+	<i>Enterobacteriaceae</i> (<i>citrobacter</i> , <i>Enterobacter</i> , <i>klebsiella</i> , <i>shigella</i> , <i>Yersinia</i> , <i>proteus salmonella</i> , <i>serratia</i>), <i>staphylococci</i> , <i>micrococci</i> and <i>Rhodococcusequi</i> .
Motility	+	+	+	+	<i>Serratiasp</i> , <i>Ochrobacteriumsp</i> , <i>Citrobactersp</i> , and <i>Enterobacteriaceae spp</i> .
Hydrogen Sulphide	+	+	+	+	<i>Serratiasp</i> , <i>Ochrobacteriumsp</i> , <i>Citrobactersp</i> , and <i>Enterobacteriaceae spp</i> .
Catalase	+	+	+	+	<i>Enterobacteriaceae</i> , <i>Klebiella</i> .
Oxidase	+	+	+	+	<i>Pseudomons</i> , <i>Neisseria</i> , and <i>Pasteurella</i>
Urase	+	+	+	+	<i>Enterobacteriaceae</i> , <i>Proteus</i> , and <i>Cryptococcus species</i>
Glucose fermentation	+	+	+	+	<i>Enterobacteriaceae</i> , <i>Proteus</i> and Others are <i>Cryptococcus species</i> , <i>Brucella</i> , <i>Helicobacter pylori</i> .
Ornithine	+	+	+	+	<i>Serratiasp</i> , <i>Citrobactersp</i> , and <i>Enterobacteriaceae spp</i> .
Lysine	+	+	+	+	<i>Serratiasp</i> , <i>Citrobactersp</i> , and <i>Enterobacteriaceae spp</i> .
Arginine	+	+	+	+	<i>Serratiasp</i> , <i>Citrobactersp</i> , 0 <i>Enterobacteriaceae spp</i> .

Sample 1: Pure isolates form Niger River, Sample2: Pure isolates form Otuocha River, Sample3: Pure isolates form Niger River, Sample4: Pure isolates form Amansea River.

Discussion

Enterobacteriaceae spp. (*Citrobacterfreundi*, *Enterobacter cloacae*, *Serratiarubidaea*) and *Ochrobactrum anthropic* bacteria are widespread in the environment and many mesophilic species contaminate food (Garcia-Armesto *et al.*, 1993), there are also psychrotrophic taxa that can multiply in refrigerated foods such as meat, fish and milk. *Serratia spp.* and *Enterobacter spp.* especially have been reported to occur in such high numbers that they actually spoil the food (Lund *et al.*, 1992; Albert *et al.*, 1992). In this study, the pure isolates were green and they are resistant to ampicillin antibiotics and this result is in line with the report of Brenner *et al.* (2005) who reported the common characteristics of the *Enterobacteriaceae spp.* which one of them is their resistance to many antibiotics.

Biochemical analysis result of this work which established that all the *Enterobacteriaceae spp.* (*Citrobacterfreundi*, *Enterobacter cloacae*, *Serratiarubidaea*) and *Ochrobactrum anthropia* bacteria are motile, oxidase positive, catalase positive, urease positive, can utilize citrate -positive, hydrogen sulphide positive, and positive to lysine, arginine, ornithine and can ferment glucose supports the report of Brenner *et al.*, (2005). The fact that these isolates can utilize citrate, hydrogen sulphide and glucose made them to be readily found in wide range of food products (Lindberg, 1997). The reason behind the ability of the *Enterobacteriaceae spp.* (*Citrobacterfreundi*, *Enterobacter cloacae*, *Serratiarubidaea*) and *Ochrobactrum anthropic* pathogenic bacteria to utilize amino acids like ornithine, lysine, arginine has not been well established (Lindberg, 1997). Gram staining of the pure isolates give gram negative reaction. This observation may be as a result of the inability of isolates to retain the crystal violet color of the gram positive bacteria. This observation supports the report of Brenner *et al.* (2005) and Donnenberg *et al.* (2015). Microscopic analysis showed that they are rod shaped and motile, the motility feature and the shape may also contribute to its wide distribution according to Lindberg *et al.* (1998).

Conclusion

Pathogenic *Enterobacteriaceae spp.* (*Citrobacterfreundi*, *Enterobacter cloacae*, *Serratiarubidaea*) and *Ochrobactrum anthropi* bacteria are established by this research work as fish pathogens in the fish from the rivers studied and can be concluded that major rivers in Anambra state harbor more than one pathogenic microorganism.

References

- Albert, M.J., Faruque, S.M., Islam, M.M., Haider, K., Alam, K., Kabir, I., Robins-Browne, R. (1992). Sharing of virulence-associated properties at the phenotypic and genetic levels between enteropathogenic *Escherichia coli* and *Hafnia alvei*. *Journal of Medical Microbiology*, 37: 310–314.
- Alfredo, G., Guglielmi, C., Basilio, M., Maria, A., Stefano, G., and Armido, O. (1987). Production of *Escherichia coli* STa-Like Heat-Stable Enterotoxin by *Citrobacter freundii* isolated from Humans. *Journal of Microbial Infection and Immunity*, 25:110-114.
- Brenner, D. J., McWorter, A. C., Leete Knutson, J. K. and Steigerwalt, A. G. (2005). *Escherichia vulneris*: a new species of *Enterobacteriaceae* associated with human wounds. *Journal of Clinical Microbiology*, 15: 1133–1140.
- De Ley, J., Mannheim, W., Segers, P., Lievens, A., Denjin, M., Vanhoucke, M. and Gillis, M. (1992). Ribosomal ribonucleic acid cistron similarities and taxonomic neighborhood of *Brucella* group. *International Journal of System Bacteriology*, 37: 35–42.
- Donnenberg, M. (2015). "*Enterobacteriaceae*". Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases, 8th Edition pp. 2503–2517.
- Fraser, S.L. (2007). *Enterobacter* Infections. eMedicine. <http://www.emedicine.com/med/topic678.htm>, 2017.
- García-Armesto, M.R., Prieto, M., Alonso, C., García-López, M. L., García-Fernández, M.C., Otero, A. (1993). Numerical taxonomy of psychrotrophic bacteria isolated from raw ewes' milk. *Journal of Dairy Resources*, 60:371–383.
- Holmes, B., Popoff, M., Kiredjian, M. and Kersters, K. (1988). *Ochrobactrum anthropi* from human clinical specimens and previously known as group. *International Journal of System Bacteriology*, 38: 406–416.
- Julie, L. B., Monique F. S., and Kwang, S. K. (1999). Detection of *Citrobacter freundii* Invasion and Replication in Human Brain Microvascular Endothelial Cells. *Journal of Microbial Infection and Immunity*, 31: 4208–4215.
- Lindberg, A.M. and Ljungh, A. (1998). *Enterobacteriaceae* found in high numbers in fish, minced meat and pasteurised milk or cream and the presence of toxin encoding genes. *International Journal of Food Microbiology*, 39: 11–17.
- Lund, A.M., Mostert, J.F., Carelsen, M.A. and Lategan, B. (1992). Proteolytic and lipolytic psychrotrophic *Enterobacteriaceae* in pasteurized milk and dairy products. *African Journal Dairy Sciences*, 24:7-10.
- MacFaddin, Jean F. (1980). *Biochemical Tests for Identification of Medical Bacteria*. HEW/CDC, Atlanta. Burgess Publishers/Corporations, pp. 441.
- Sarkar, A., Mousumi, S. and Parnab, R. (2013). Detection of 232bp Virulent AHCTONE Gene of Pathogenic *Aeromonas* spp. Through a rapid Molecular Diagnostic Approach. *Journal of Biotechnology*, 3:83-87.
- Velasco, J., Romero, C., Lopez-Goni, I., Leiva, J., Diaz, R. and Moriyon, I. (1998). Evaluation of the relatedness of *Brucella* spp. and *Ochrobactrum anthropi* and description of *Ochrobactrum intermedium* sp. nov., a new species with a closer relationship to *Brucella* spp. *International Journal of System Bacteriology*, 48:759–768.
- Williams, K. P.; Gillespie, J. J.; Sobral, B. W. S.; Nordberg, E. K.; Snyder, E.E.; Shallom, J. M.; Dickerman, A. W. (2010). Phylogeny of Gammaproteobacteria. *Journal of Bacteriology*, 192 (9): 2305–2314.
- Yu, C.F., Peter, H.F. and Qun, Y. (2004). Novel Species of Tetrodotoxin Producing-Bacteria from Toxic Marine Puffer Fish. *Journal of Toxicology*, 44: 641-647.

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Vaccine Applications and Bio security Measures: A viable Tool for Disease Management in Aquaculture**Onwujiariri, C.E., Akinrotimi, O.A ., Eze, B.U and Iteze, P**

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Abstract

Aquaculture has grown rapidly worldwide in recent years. Aquatic animal diseases are the most significant constraints to the development and management of aquaculture. As aquaculture is growing rapidly and poised to help in bridging the gap in the global supply and demand of aquatic animal food products, management of health and reducing losses due to disease in aquaculture is gaining high priority. One of the key areas of success in managing aquatic animal health in aquaculture has been the development of vaccines and maintenance of good hygiene. There has been significant progress in vaccination against certain diseases and pathogens; however, vaccines are not yet available for many important diseases. Science and research into vaccination is progressing well and there is hope that more vaccines will be available in the coming years as immunoprophylaxis and bio security measures holds the key to effective health management of fish in the culture medium . This review aims at pointing out some of the best approaches to prevention and control of infectious disease in aquaculture. Among the effective prevention and control strategies, vaccination is one of the key practices. Types of vaccines for use in fish include killed vaccines, attenuated vaccines, DNA vaccines, recombinant technology vaccines, and synthetic peptide vaccines. Administration techniques of vaccines in fish include oral, injection, or immersion methods In conclusion, rather than trying to treat every disease case, it advisable to follow a preventive approach before the event of any disease outbreaks.

Keywords: Vaccination, Aquaculture, Health management, Disease.**Introduction**

Fisheries play a great role in food security and livelihood and are a source of income and social development in developing countries (FAO, 2016). Recently the sector attracted great attention and it is growing rapidly through the development of aquaculture. New technological advances and increased demands for fish as a source of animal protein are the main reasons for the industry's growth. Because of expansion of the industry, the culture methods have become more intensive for producing higher yields (Katiha, 2015). However, disease is a primary constraint to the growth of many aquaculture species, and is now responsible for severely impeding both economic and socio-economic development in many countries of the world. Addressing health questions with both pro-active and reactive programmes has, thus, become a primary requirement for sustaining aquaculture production and product trade. There is now convincing evidence of the serious socio-economic, environmental and international trade consequences arising from trans-boundary aquatic animal diseases (Vijayan and Sanil, 2012).

To overcome losses because of infectious diseases in aquaculture, it is necessary to act upon every health constraint based on scientifically proven and recommended as well as locally applicable ways. Challenges in aquaculture because of climate change, limited water sources, and the growth drive the need for epidemiological approaches in keeping aquatic animal health safe. As “prevention is better than treatment,” it is advisable to focus on preventing the occurrence of disease rather than treating it (Dhar *et al.*, 2014). In different parts of the world the ban on the use of antibiotics is still in place. In response to reduced antibiotic use in fish, productions of vaccines have been playing a key role in infectious disease control in aquaculture for decades. Vaccines get wide acceptance for the fact there is no risk of drug resistance development in vaccinated animals and protection of minority unvaccinated animals because of herd immunity (Cho *et al.*, 2017). Biosecurity measures in aquaculture can keep the safety of a facility from certain disease-causing agents that are absent in particular system. Farm-level biosecurity measures include strict quarantine measures, egg disinfection, trafo control, water treatments, clean feed, and disposal of mortalities. In conclusion, rather than trying to treat every disease case, it advisable to follow a preventive approach before the event of any disease outbreak (Siddick *et al.*, 2014). A single approach to prevention and control of aquaculture health is not successful alone. Rather a combination of different strategies is effective.. This review elucidates some of the best approaches to prevention and control of infectious disease of fish in an aquaculture environment.

Types of Fish Diseases

Bacterial diseases

Bacterial fish diseases are very common and are one of the most difficult health problems to deal with. These bacteria are generally saprophytic in nature and only become pathogenic when fishes are physiologically unbalanced, nutritionally deficient, or there are other stressors, i.e., poor water quality, overstocking, which allow opportunistic bacterial infections to proceed. Bacterial diseases have been frequently encountered in eggs, fry, fingerlings of fish, causing heavy mortality. These microorganisms are essentially opportunistic pathogens which invade the tissues of a fish host rendered susceptible to infection by stress factors (Shaoqi, 1989).

Parasitic diseases of fish

The production from culture system is hampered by the infestation of various fish parasites. Compared to other diseases, occurrence of parasitic disease has been the major cause of concern and caused significant setback to freshwater aquaculture in India [20]. Fish parasites multiply rapidly under favourable conditions, thereby affecting the health of fishes, often leading to high mortality. Parasites interfere with nutrition of hosts, disrupts metabolism and secretory functions of alimentary canal and damage nervous system (Sahoo *et al.*, 2017).

Fungal diseases of fish

Contrary to bacterial and parasitic diseases, only a few number of fungal species are known to be pathogenic to fish. Mostly these are present in water and under unfavourable conditions, they attack the fish causing skin lesions. Most fungal infections recorded in carp culture are those caused by species belonging to the oomycete fungi, *Saprolegnia*, *Achlya* and *Aphanomyces*. Diseases caused by these fungi are collectively called “saprolegniasis” (Mishra *et al.*, 2015).

Viral diseases for fish

There are more than 125 different viruses have been identified in fish around the globe and new viruses are being discovered every new date. However, there are only few reports of viral diseases affecting finfish in some countries around the world (Mishra *et al.*, 2015).

The Role of Vaccines in Control and Prevention of Infectious Disease in Aquaculture Advancing vaccination is one of the most important, and probably the priority, approaches to prevention and control of infectious disease of fish. Treating many of the bacterial infections in aquatic animals using antimicrobials only is impossible. There are improvements in fish vaccination recently. Some of the improvements include immunization of large stock at a time and the development of multivalent vaccines (Sahoo *et al.*, 2017).. Vaccination is widely in use in almost all food producing animals. In aquaculture, it reduces the use of antibiotics and protects fish from infectious diseases. It also avoids the risk of drug resistance. Protection at stock level because of herd immunity can be achieved and the need for licensing and registration of new vaccine is much easier than antibiotics (Adams, 2016). There are few important considerations that should be taken into account before application of vaccination in fish. These considerations include the following points: fish species to be vaccinated, status of the immune system of the fish, production cycle, and life history of the aquaculture system, which diseases need to control in aquaculture, when do these diseases occur (seasonal distribution of diseases in the aquarium), farming technology (handling and mechanization), environment (temperature and salinity), stress factors, nutrition, and cost benefit (Mweemba *et al.*, 2014).

Historical Overview of Fish Vaccination.

Fish vaccination was started by vaccinating against *Aeromonas salmonicida* infection in Cutthroat in 1942. Currently, vaccines in use are the conventional type of vaccines because of lack of advanced information on the immunology of fish. Vaccines available are oil adjuvant, injectable vaccine. The salmon genome is now fully sequenced, the genome and several other fish species as well. These findings can lead to novel vaccine development strategies in near future [15]. Vaccines against intracellular bacterial and viral pathogens will be one of the big challenges for the coming years. DNA vaccine will play a role in such cases (Rogers and Basurco, 2009).

Types of Fish Vaccines.

Modern vaccines can be classified as killed, attenuated, DNA, synthetic peptide, recombinant vector, genetically modified, and subunit vaccines. Whole organism vaccines showed a better advantage than other types of vaccines. However, most of the vaccines do not completely prevent disease. That is why advanced technologies of vaccine designing strategies are developed for the discovery of newer types of effective vaccines (Lien *et al.*, 2016).

Killed Vaccines. Killed vaccines are conventional types of vaccines prepared by killing the infectious agent and using it as an antigen to induce an immune response. Most of the commercial vaccines currently used in aquaculture are killed vaccine types. The advantages of these vaccines are as follows: they are easy to design, are stable in storage, and are less expensive and there are no virulence issues (Lien *et al.*, 2016).

Attenuated Vaccines. These are also conventional vaccines which are used in food-producing animals and humans to prevent disease [18]. They are prepared by repeated laboratory passage, physical and chemical attenuation of the organisms to lose their virulence without killing them. (Lien *et al.*, 2016).

Deoxyribonucleic Acid (DNA) Vaccines. They are a recent type of vaccines which are the result of the advancement of molecular biology. To develop a DNA vaccine, there is no need to use the antigen as a vaccine, rather the gene that code for the antigen is taken by molecular techniques and can be given as a vaccine [21]. DNA vaccines contain one or more genes of a pathogen. Intramuscular injection of these vaccines confers immediate and a durable protection from diseases in farmed salmonids against economically important diseases such as infectious hematopoietic necrosis (Lien *et al.*, 2016).

Recombinant Vector Vaccines. Recombinant vector vaccines are the result of biotechnological advancement prepared by taking only the immunogenic regions of a pathogen and expressing it in a heterologous host. The immunogenic part of the organism taken and expressed to carriers. The proteins are then produced in large quantities in vitro and then purified for use as a vaccine (Lien *et al.*, 2016).

Genetically Modified Vaccines. In vitro passaging of organisms results in a build-up of genome mutations that make the organism weaken. Genetically, microorganisms may be attenuated by molecular approaches that involve removal of genes responsible for its pathogenicity. Live attenuated vaccine will replicate to a lower titer and can stimulate humoral and cellular immunity. (Lien *et al.*, 2016).

Synthetic Peptide Vaccines. These types of vaccines are produced from short sequences of amino acids prepared synthetically to act as antigens. These can be used as a suitable antigenic site. Studies showed that vaccinating fish with peptides is less practicable because of lack of understanding the fish immune response to different antigens and being not potent enough and thus requires a carrier molecule (Lien *et al.*, 2016).

Methods of Administering Vaccines to Fish.

Successful vaccination depends upon both the development of protective vaccines and their correct use. Besides deciding which diseases to vaccinate is necessary to clearly understand how to administer vaccines and when to administer a booster dose (booster dose) must be considered. For best protection, vaccination should be carried out sometime before exposure to the pathogen, to give immunity plenty of time to develop. Water temperature may be an important factor when deciding when to vaccinate, as well as the size of fish, being the major feature regulating the development of immune competence (Rico *et al.*, 2012).

1. Oral Vaccination. Oral vaccination is easy to apply and avoids stress in fish. The vaccine is incorporated to the feed during production, or it may be coated with pellets or encapsulated. Oral vaccination is recommended for secondary or booster vaccinations. A disadvantage of oral vaccination includes that it may not give a uniform protection and requires a large dose, and it may have additional cost of encapsulation (Rico *et al.*, 2012).

2. Immersion Vaccination. When applying immersion, vaccines are applied to the surfaces of the fish. The antigen uptake is via the gills, the skin, and the lateral line. The fish may be dipped for a short period of time in concentrated vaccine solution. The vaccine solution may also be sprayed onto the fish. Immersion vaccination is particularly convenient for small fish and fingerlings, which are impractical to handle for injection; the other advantage is that it causes minimal stress in fish (Rico *et al.*, 2012).

Injection Vaccination. Vaccination by injection is the delivery method generally resulting in best protection and is the only choice for adjuvant vaccines. The advantages of injecting a vaccine are attaining high protection and needing relatively minimal dose because correct dosage calculation is easy and economical for larger fish, and a multivalent vaccine can be administered. The disadvantages of this administration are as follows: not suitable for small fishes (Rico *et al.*, 2012).

Biosecurity Measures in Aquaculture

Biosecurity is any management action to prevent the introduction of disease-causing agents to aquaculture facility. Farm-level biosecurity measures involve the application of a combination of activities more or less which includes strict quarantine measures, sanitation of equipment, disinfection of egg, traffic control, water treatments, use clean feed, disposal of dead appropriately. These protocols should be implemented during the introduction of new stock as well as implementing them for reducing pathogens and to avoid transferring pathogens from one stock to another. Most diseases of aquaculture can be overcome by meticulous application of biosecurity measures (Romero et al., 2012).

Challenges in Prevention and Control of Fish Disease

In relative terms, it is fair to say that infectious disease control in aquaculture is more complicated than terrestrial animal disease control due to environment where fish lives, and the nature of the fish themselves because fish cannot be observed close enough like we do in terrestrial animal, the environment can facilitate disease transmission quickly, fish are not caged easily without stress, they often gather in groups, and disease is often difficult to detect and characterize (Mishra *et al.*, 2015). The other important challenge is in diagnosing disease of fish; in terrestrial animal disease diagnosis, the individual animal is the unit of interest. The scenario is not the same in aquaculture disease investigation because of the nature of the water where fish lives (Mishra *et al.*, 2015).

Conclusion

It is clear that aquaculture is a huge industry operating worldwide and growing rapidly. The sector has been facing many constraints and challenges which are sophisticated and multifaceted. Among these challenges, infectious diseases take the lion share causing billion-dollar loss annually. Therefore, problem planning prevention and control strategy based on globally accepted principles and locally applicable strategies are recommended. These strategies should focus on preventing the development of infection rather than treating diseased stocks. Generally, the use of a combination of immunoprophylaxis, biosecurity measures, and use of only legally approved antibiotics can result in ultimate health protection of fish in aquaculture.

References

- Adams, A. (2016). *Fish Vaccines*, Springer Science+Business Media, Basel, Switzerland, 1st edition, 2016.
- Cho, H. J. Kim, N. T. Lan D (2016)., "Oral vaccination through voluntary consumption of the convict grouper *Epinephelus septemfasciatus* with yeast producing the capsid protein of redspotted grouper nervous necrosis virus," *Veterinary Microbiology*, vol. 204, pp. 159–164, 2017.
- Dhar, S. K. Manna, and F. C. T. Allnutt, (2014). "Viral vaccines for farmed finfish," *Virus Disease*, vol. 25, no. 1, pp. 1–17, 2014.
- FAO, *The State of World Fisheries and Aquaculture, Contributing to food security and nutrition for all*, Food and Agriculture Organization of the United Nations, Rome, Italy, 2016.
- Katiha P/K (2000) *Freshwater aquaculture in India: Status, potential and constraints*. Proceedings of the Aquaculture Development in India: Problems and Prospects Workshop. In: Krishnan M, Borthal PS (eds.). National Centre for Agricultural Economics and Policy Research, New Delhi, India.
- Lien, B. F. Koop, S. R. Sandve H (2016)., "The Atlantic salmon genome provides insights into rediploidization," *Nature*, vol. 533, no. 7602, pp. 200–205, 2016.
- Mishra SS, Dhiman M, Swain P, Das BK (2015). *Fish diseases and health management issues in aquaculture*. ICAR-CIFA Training manual No.18, Central Institute of Freshwater Aquaculture, Bhubaneswar, India.
- Mweemba, S. Mutoloki, and E. Øystein, (2014). "Non Replicating vaccines," in *Fish Vaccination*, R. Gudding, A. Lillehaug, and Ø. Evensen, Eds., pp. 22–29, John Wiley & Sons, Inc, Oxford, 1st edition, 2014.
- Rico, K. Satapornvanit, M. M. Haque, L (2012), "Use of chemicals and biological products in Asian aquaculture and their potential environmental risks: A critical review," *Reviews in Aquaculture*, vol. 4, no. 2, pp. 75–93, 2012.
- Rogers, A and B. Basurco, (2009). "Antimicrobial agents in aquaculture: Practice, needs and issues," *CIHEAM*, vol. 59, pp. 41–59, 2009.
- Romero, C. G. Feijoo, and P. Navarrete, (2012) "Antibiotics in aquaculture Use, abuse and alternatives," *Health and Environment in Aquaculture*, pp. 160–198, 2012.
- Sahoo P.K, Pradhan PK, Sundaray JK, Lal KK, Swaminathan TR (2017) *Present Status of freshwater fish and shellfish diseases in India*. In : Proceedings of International Symposium on aquatic Animal Health and Epidemiology for sustainable Asian A Ayyappan S (2004) *Enhancing global competition. Survey of Indian Agriculture*. The Hindu 97-100.

- Shaoqi Li (1989). Main fish diseases and their control. In: Integrated Fish Farming in China (ed.). NACA Technical Manual 7. A World Food Day Publication of the Network of Aquaculture Centres in Asia and the Pacific, Bangkok, Thailand.
- Siddick SA, Durairaja R, Oliverking EdI (2014) Freshwater Fish Culture in Agro-biodiversity Hot spots, Community Initiative in India. Presented in International Food Security Dialogue: Enhancing Food Production, Gender Equity and Nutritional Security in a Changing World.
- Vijayan K.K, Sanil N.K (2012). Health Management Strategies for profitable and sustainable Aquaculture, with special reference to diagnostics. In: Swain SK, Swain P, Pillai BR, Raghunath MR Jayasankar P (eds.). Lead papers on strategies for Aquaculture Development. ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar, India.

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Parasitic Infection In Tilapia And Catfish: A Comparative Assesment Of Wild And Cultured Fishes Obtained From N.A.B.D.A, Dankasa Fish Farms And Ajiwa Water Reservoir In Katsina, North-Western Nigeria

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Abstract

A comparative parasitological investigation was carried out during the period of June to November 2019, to access the infestation of parasites associated with *Tilapia zillii* and *Clarias gariepinus* in Ajiwa water reservoir in comparison with some fish farms in Katsina. A total of 330 fish samples, comprising of 110 each from NABDA and Dankasa fish farms, and Ajiwa water reservoir were examined. The fins, skin, gills and the gastrointestinal tract was examined for parasites using standard procedure. Parasite species were encountered were; 4 the protozoans: *Trichodina acuta*, *Ichthyophthirius multifiliis*, *Chilodonella piscicola*, *Ichthyobodo necator* and 7 helminths including (cestodes): *Diphyllobothrium latum*(eggs); (trematodes): *Neascus* sp., *Gyrodactylus* sp., *Dactylogyrus* sp. and (nematodes): *Procamallanus laevionchus* and *Contracaecum multipapillatum*. *Ichthyophthirius multifiliis* were the most common parasites found in water reservoir and fish farms' samples examined. Of the 330 fish samples examined, 99(30.0%) were infected with at least one parasite. The ectoparasitic infections were 21.82%, 12.73% and 63.64% respectively for NABDA, Dankasa fish farms and Ajiwa water reservoir, while respective endoparasites infections were 4.55%, 4.55% and 51.82%.

Key words: Ectoparasites, Endoparasites, *Clarias gariepinus*, *Tilapia zillii*, Ajiwa water reservoir, N.A.B.D.A and Dankasa fish farms.

Introduction

Parasites have a wide-ranging distribution in all groups of animals (Ali, 2018). They are more abundant than free-living animals, and may be established in most groups of animals from protists to chordates (Kuris *et al.*, 2008). An enormous number and diversity of animal species are capable of parasitizing fish, ranging from minute protozoans to easily visible crustaceans and annelids (Bush *et al.*, 2001). Most of the fishes, either wild or farmed, are infected with parasites (Mokhtaret *et al.*, 2014). They not only serve as the host to diverse parasites, but also serve as carriers of many larval parasitic forms that mature and cause severe diseases in many vertebrates, including man (Assafa *et al.*, 2004). Parasites exhibit amazing strategies for adaptation to their hosts. Many parasite species are host-specific to some extent and are capable of infecting one or only a restricted number of host species. Individual parasite species may also have widely dissimilar effects on different host species (Poulin, 2011). Some of them are parasitic on the skins of fish; others are parasitic in the interior organs. Parasites hamper the nutrition, metabolism, and secretory function of the alimentary canal, damage nervous system, and reproduction of the host (Alvarez-Pellitero *et al.*, 2004).

Most fish particularly in the wild population are likely to be infected with parasites, but in the great majority of cases, no substantial harm to the host may be ensued or identified; thus, there are only few reports of parasites causing death or serious harm to the fish populations, but this may be mostly because such effects go unobserved (Roberts, 2001). Fishermen or consumers often detect parasites in wild fish only when they are so evident as to lead to rejection of fish (Roberts, 1995). In farmed fish population, on the other hand, parasites often cause severe occurrence of disease. According to Roberts *et al.* 2000, the most diverse and common pathogens the aquaculturist may likely encounter are parasites, and parasitic infections are very common in fish all over the world and are of particular significance in the tropics.

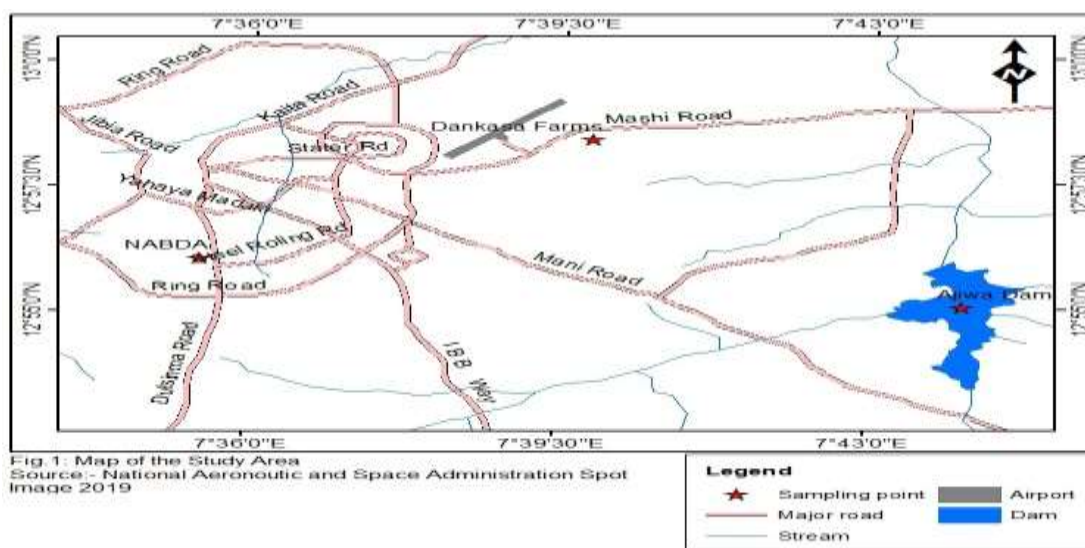
The commonest fish cultured in Nigeria are the catfish species of *Clarias gariepinus* and *Clarias angularis*. The sharp mouth catfish, *Clarias gariepinus* (Burchell, 1822) is widely distributed in Africa (Skelton, 2001; Barson, 2003) occurring mostly in quiet waters, lakes and ponds but may also occur in fast flowing rivers (Ayanda, 2009). It is highly valued in Nigeria either as a smoked, dried or fresh delicacy (Imam and Dewu, 2010), and are a very good species for aquaculture and biological enquiry (Hoffman and Prinsloo, 1996). Numerous phyla of the animal

kingdom have representatives that are parasites of *T. zillii*. In Nigeria, there is a main group of parasites involved in *T. zillii* parasitism (Ndifon and Jimeta, 1990; Awa *et al.*, 1996). These include trematodes *Clinostomum sp.*, *Euclinostomum sp.* and nematode *Procamallanus sp.* as reported by Ukoli (1988) and Okaeme (1991). This study reports comparison of parasitic protozoan and helminth infection between the farmed and wild species of *C. gariepinus* and *T. zillii* from N.A.B.D.A, Dankasa fish farms and Ajiwa water reservoir in Katsina, North-Western Nigeria.

Materials and Methods

Sampling location

Samples were collected from Ajiwa water reservoir. It was built in 1976 in Ajiwa District (lies between latitude 12° 98' and 12° 58' E and longitude 7° 75' N and 7° 45' E) in Batagarawa Local Government Area in Katsina State, Nigeria, to provide water for general household use and irrigation. The deepest point of the dam is approximately 40 meters and the stretch of the dam is approximately 22 km long. Additionally, samples were also collected from two fish farms; National Biotechnology Development Agency (NABDA) and Dankasa integrated farms (Fig. 1).



Collection, identification and examination of fish samples

110 cultured fish samples consisting of 55 *C. gariepinus* and 55 *T. zillii* were collected from each fish farm. Sample collections were done in the morning between 06:00am and 08:00am. At the water reservoir, the fish were captured using cast nets by local fishermen. Samples were held in water from the collection site and transported to the postgraduate laboratory of Department of Biology, Umaru Musa Yar'adua University, Katsina in aerated plastic containers for further analysis. At the laboratory, the fishes were given serial number and the fish morphometric data were obtained prior to fish parasites analysis as described by Abba *et al.*, (2018). Sex was ascertained by inspection of the external reproductive structures as reported by Akinsanya, (2015). Fish were euthanized by cervical dislocation for ease of examination (Abba *et al.*, 2018).

Isolation of ecto and endoparasites

The whole external body surface of a freshly caught fish was meticulously examined for ectoparasites using hand lens. Mucous from dorsal part of the body of fish was scraped, lateral and tail ends were positioned on a clean glass slide with a drop of normal saline added and observed under x10 and x40 of a dissecting microscope (Okoye *et al.*, 2014). In case of external indication of infection (lesion or spots), a small segment of the affected body surfaces was cut and placed in aqueous 4% formalin for 30 minutes. The mixture was shaken briskly to dislodge relaxed parasites and then viewed under a dissecting microscope (Biu *et al.*, 2014).

In isolation of endoparasites, the body cavity was cut open with the aid of a pair scissors and the gut was then stretched out and placed in a large Petri dish and cut into four regions (Oesophagus, stomach, intestine and anus). Each organ was then placed in a separate labeled dish. The separated gut regions were incised longitudinally to expose the inner surface which was washed with very little normal saline into labelled test tubes and left for

sedimentation. A droplet of the residue after decantation of upper layers of the sediment was placed in a slide and examined under x10 and x40 objectives of dissecting microscope for parasites. This was repeated until all the residue was examined (Ajala and Fawole, 2014). The operculum of the fish was cut open with scissors and gills were extracted. Gill arches and gill filaments were placed in different Petri dishes holding normal saline and were examined with hand lens and dissecting microscope for parasites (Biu *et al.*, 2014).

Identification of parasites

Identification of the isolated parasites to species level was done by comparing observed parasites using keys by Yagamuti, (1959); Barson and Avenant-Oldewage, (2006), and Scholz *et al.*, (2018).

Results

Out of 330 fish samples examined for parasites 100(30.30%) were infected with 235 parasites of both protozoan and helminth species. Infection by both helminths and protozoans was recorded only in wild fish samples while farmed fish harboured only protozoans. Of the 55 *C. gariepinus* from Ajiwa water reservoir 32(58.18) were infected with 7 parasites; 1 ciliate *Ichthyophthirius multifiliis* (3.64%) and 6 helminth parasites including *Procamallanus laevionchus*(30.91%), *Contracaecum multipapillatum*(3.64%), *Diphylobothrium latum* (eggs)(9.09%), *Dactylogyrus* sp. (20.00%), *Gyrodactylus* sp. (7.27%) and *Neascus* sp.(36.36%)(Table 1)

Figure 1 showed a comparison of prevalence of parasitic infection between farmed and wild fish species. Wild fishes had a higher prevalence of 51.82% while NABDA and Dankasa fish farms had respective lower prevalence of 22.73% and 16.36%.

Table 1: Prevalence of Parasites in skin/fin, gill and GIT of *C. gariepinus* from Ajiwa water reservoir.

Parasite species	No of fish infected by each parasite (Prevalence %)	Location of recovered parasite
<i>Neascus</i> sp.	20 (36.36)	Skin
<i>Ichthyophthirius multifiliis</i>	5 (3.64)	Skin
<i>Dactylogyrus</i> sp.	9 (20.00)	Gill
<i>Gyrodactylus</i> sp.	7 (7.27)	Gill
<i>Procamallanus laevionchus</i>	22 (30.91)	GIT
<i>Contracaecum multipapillatum</i>	14 (3.64)	GIT
<i>Diphylobothrium latum</i> (eggs)	5 (9.09)	GIT

Tilapia zillii from the wild was positive for 5 parasites including: *Procamallanus laevionchus*, *Clinostomum tilapiae*, *Dactylogyrus* sp., *Contracaecum multipapillatum* and *Neascus* sp. (Table 2).

Table 2: Prevalence of Parasites in skin/fin, gill and GIT of *T. zillii* from Ajiwa water reservoir.

Parasite species	No of fish infected by each parasite (Prevalence %)	Location of recovered parasite
<i>Neascus</i> sp.	8 (9.09)	Skin
<i>Clinostomum tilapiae</i>	10 (18.18)	Skin/Gill
<i>Dactylogyrus</i> sp.	28 (29.09)	Gill
<i>Procamallanus laevionchus</i>	22 (30.91)	GIT
<i>Contracaecum multipapillatum</i>	9 (10.91)	GIT

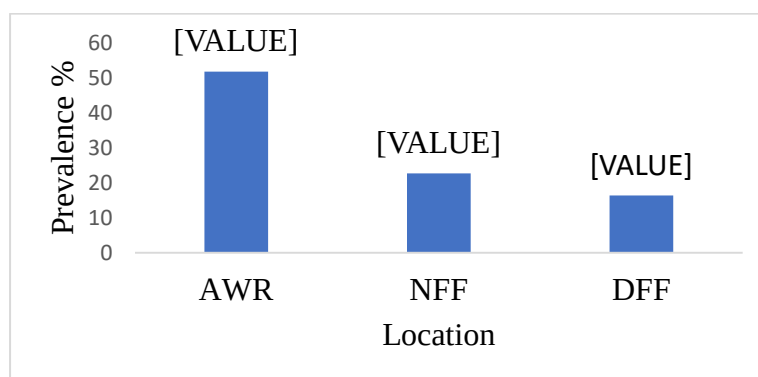
Table 3 and 4 showed farmed fishes from both locations were infected with 4 species of protozoans: *Ichthyobodo necator*, *Chilodonella piscicola*, *Trichodina acuta* and *Ichthyophthirius multifiliis* which were recovered in the two farmed fish species on skin/fin, gill and GIT.

Table 3: Prevalence of Parasites in skin/fin, gill and GIT of *C. gariepinus* from both fish farms.

Parasite species	No of parasites from N.A.B.D.A fish farm (Prevalence %)	No of parasites from Dankasa fish farm (Prevalence %)	Location of recovered parasite
<i>Ichthyophthirius multifiliis</i>	8(9.09)/7(7.27)/3 (3.64)	6(7.27)/5(5.45)/3(5.45)	Skin/Gill/GIT
<i>Chilodonella piscicola</i> :	5 (5.45)	2 (1.82)	Skin
<i>I. necator</i>	3 (5.45)	1 (1.82)	Gill
<i>Trichodina acuta</i>	2 (1.82)	3 (1.82)	GIT

Table 4: Prevalence of Parasites in skin/fin, gill and GIT of *T. zillii* from both fish farms.

Parasite species	No of parasites from NABDA fish farm (Prevalence %)	No of parasites from Dankasa fish farm (Prevalence %)	Location of recovered parasite
<i>Ichthyobodo necator</i>	6 (5.45)/ 3 (5.45)	3 (3.64)/ 1 (1.82)	Skin/ Gill
<i>Chilodonella piscicola</i>	1 (1.82)	1 (1.82)	Skin
<i>I. multifiliis</i>	5 (7.27)/2 (1.82)	2 (1.82)/2 (1.82)	Gill/GIT
<i>Trichodina acuta</i>	2 (1.82)	---	GIT

**Prevalence of parasitic infection in wild and in fish farms**

Key: AWR=Ajiwa water reservoir, NFF=NABDA fish farm, DFF=Dankasa fish farm

Discussion

The comparative examination of ecto, gill and GIT parasites of two fish species i.e tilapia and catfish in three different locations i.e NABDA fish farm, Dankasa fish farm and Ajiwa water reservoir revealed that Ajiwa water reservoir had the highest parasite burden in both species of fish with a prevalence of 51.82%. This was higher than 27.88% that was reported by Abba *et al.*, 2018 also from Ajiwa water reservoir, this may be linked with several activities going on in the reservoir's water which may heighten the chance of fish to come in contact with infections (Udechukwu *et al.*, 2018).. N.A.B.D.A fish farm had a prevalence value of 22.73%, while Dankasa fish farm had 16.36% as its prevalence value which agrees with Udechukwu *et al.*, (2018) in Bauchi.

Ichthyophthirius multifiliis was the only protozoan parasite found in all sites of infection across the locations. This agrees with a number of studies in northern Nigeria by Udechukwu *et al.*, (2018) and Omeji *et al.*, (2011).

I. multifiliis caused wearing away of the epithelium and stiffening of the gills and could be attributed to inflammatory change which occurred during infection with these parasitic ciliates as described by Singh *et al.*, (2004). Other protozoan parasites isolated include, *Trichodina acuta* which also caused elimination of epithelium and excess mucus assembly which result in casing of the infected fins and gills with thick layer of mucus as reported by Ali, (2018). Most parasites in the alimentary canal of fish are disease-causing. The pathological effects are as a consequence of mechanical injury that is caused by the organs of attachment (Udechukwu *et al.*, 2018). Other protozoans include *Chilodonellapiscicola* found on skin and *Ichthyobodo necator* on the gills. These parasites were reported to infect fish gills as reported by Ogbu *et al.*, 2019.

Neascus sp. recovered from the skin and fin of Tilapia have been reported by Simon-oke (2016). *Clinostomum tilapiae* found on skin and gill of Tilapia has been found by earlier studies by Bichi and Ibrahim, (2009) and by Ebube, (2014).

The trematode *Clinostomum tilapiae* recovered as ectoparasites of Tilapia were also found parasitizing the gills of the same species of fish as observed by Bichi and Ibrahim (2009) and Ebube, 2014. The other two helminth species recovered at Ajiwa water reservoir i.e. the monogenous trematodes; *Dactylogyrus sp.* and *Gyrodactylus sp.* have been found in Tilapia and Catfish species by Goselle *et al.*, (2008).

Procamallanus laevionchus recovered from the GIT of both Tilapia and Catfish were also recovered by Ayanda, (2008). The nematode *Contracaecum multipapillatum* recovered in tilapia and catfish was also reported by Biu *et al.*, (2014). The eggs of the cestode *D. latum* recovered in the GIT of Catfish as was recorded by Odohet *al*, (2019) and by Abidemi-Iromini and Adelegan (2019).

The high degree of parasitic infection in males than the female in this study, agrees with the reported work of Oniye *et al.*, (2004) who reported high prevalence of infection in male fish than in female fish. The cause of higher infection in males may be that the male fish could be more energetic than females for the duration of the breeding period and so are disposed to infection by the parasite or its infective stage.

Conclusion

Comparative assessment of two species of wild and farmed fishes (catfish and tilapia) from Ajiwa water reservoir and some fish farms in Katsina shows that fish from Ajiwa water reservoir had a higher parasite burden than the two fish farms.

Recommendation

- i. From the findings of this research, fish farmers that may want to obtain their brood stock from Ajiwa water reservoir must quarantine and treat them, so they are parasite-free, this will help curtail the spread of these parasites into cultured systems.
- ii. Further research on these species of fish or even other species should look extensively into the seasons for at least a year to establish a proper trend in parasitic infection.

References

- Abba A.M., Emere M.C. and Appah J. (2018). Comparative study on Helminth Parasites of *Oreochromis niloticus* and *Clarias gariepinus* in Ajiwa Earth Dam, Katsina State, Nigeria. *World Journal of fish and Marine Sciences*, 10(1): 05 – 11.
- Abidemi-Iromini, A. O. and Adelagan R. A. (2019). Growth status and parasitic fauna of *Clarias gariepinus* collected from Ogbese River and Owena River South-west Nigeria. *Journal of Agriculture and Ecology Research International*. 19(2): 1-12.
- Ajala O.O. and O.O. Fawole (2014). Multiple infections of helminths in the stomach and intestine of *Clarias gariepinus* (Burchell, 1822) in Oba Reservoir, Oyo State, Nigeria. *Journal of pharmacy and Biological sciences* 9(3): 05 – 12.
- Akinsanya, B., (2015). A two fish species study of the parasitic helminth fauna of *Synodontisfilamentosus* (Boylenger, 1901) and *Calamoichthyscalabaricus* (Smith, 1865) from Lekki Lagoon, Lagos, Nigeria. *Ife journal of science*, 17(1): 97 – 108.
- Ali, A. F. (2018). *Fish parasite: infectious Diseases Associated with Fish parasite*. Seafood safety and Quality, 144 pp.
- Alvarez – Pellitero, P., Barja, J.L., Basuxo, B., Berthe, F., and Toranzo, A.E. (2004). *Report about fish parasitic diseases*. Mediterranean aquaculture diagnostic laboratories, 103 – 130pp.
- Assafa, D., Kibru, E., Nagesh, S., Gebreselassie, S., Deribe, F., and Ali J. (2004). *Medical Parasitology USAID*, pp. 1 – 3.
- Awa, J.U., Ugumba, A. and Ocaibo, A.B. (1996). Parasites of *Oreochromis niloticus* of a lake, Ibadan, *Parasitism*, 17: 115 – 120.
- Ayanda, O.I. (2008). Comparison of parasitic health infection between the sexes of *Clarias gariepinus* from Asa Dam Ilorin, north-central Nigeria *Scientific Research and Essays*. 4,4, 357 – 360.
- Barson, M. (2003). The occurrence of *Contacaecum sp.* Larvae (Nematoda: Anisakidae) in Catfish, *Clarias gariepinus* (Burehell, 1822) from Retrial Dam, South Africa. *Onderstepoort Journal of Veterinary Research*, 73: 87 – 94.
- Barson, M. and Avenant-Oldewage, A. (2006a). On Cestodes and digenea parasites of *Clarias gariepinus* (Burchell, 1822) from Retrial Dam, South Africa. *Onderspoort Journal of Veterinary Research*, 73: 101 – 110.
- Bichi, A. H. and Ibrahim, A. A. (2009). A survey of ecto and intestinal parasites of *Tilapia zillii* (Gervias) in Tigalake, Kano, Northern Nigeria. *Bayero Journal of pure and applied sciences*. 2 (1): 79-82.
- Biu, A.A., Diyaware, M.Y., Yakaka, W. and Rita, D.J. (2014). Incidence of parasites of *Clarias gariepinus* (Burchel, 22) caught from lakeAlau Maiduguri, Borno State, Nigeria. *Nigerian Journal of Fisheries and Aquaculture*, 2 (1): 74 – 80pp.
- Bush, O.A. Fernandez, J.C., Esch, G.W. and Seed, R.J. (2001). *Parasitism: the diversity and ecology of animal parasites*. Cambridge University Press, 60pp.

- Ebube, C. A. (2014). Prevalence, intensity and abundance of endoparasites in *Oreochromis niloticus* and *Tilapia zillii* (Pisces: Cichlidae) from Asa Dam, Ilorin, Nigeria. *UNED Research Journal*. 7(1): 67-70.
- Goselle, O. N., Shir G. I., Udeh E. O., Abelau, M. and Imandeh, G. N. (2008). Helminth parasites of *Clarias gariepinus* and *Tilapia zillii* at Lamingo dam, Jos, Nigeria. *Science World Journal*. 3: 23-28.
- Hoffman, A.C. and Prinsloo, J.F. (1996). *The potential of freshwater fish in South Africa*. Food Industries South Africa, 30:1 – 2.
- Imam, T.S. and Dewu, R.A. (2010). Survey of piscine ecto and intestinal parasites of *Varias* sp. Sold at Galadima road fish market, Kano metropolis, Nigeria *Bioscience Research Communication*, 22(4):209.
- Kuris, A., Hechinger, R., Shaw, J. (2008). Ecosystem energetic implications of parasite and free-living biomass in three estuaries. *Nature*:454: 515-518.
- Mokhtar, I.K. Isma'il, S.E. and Hussien, S.A. (2014). Studies on some fish parasites of public health importance in the southern area of Saudi Arabia. *Brazilian Journal of veterinary Parasitology*, 23:435 – 442
- Ndifon, G.T. and Jimeta, R.S. (1990). Preliminary observation on the parasites of *Chryrichyesaurantus* (Geoffery) in Tegalake, Kano, Nigeria. *Journal of parasitology*. 9 (11): 139 – 144.
- Odoh Victoria Ugbede, AbuhOjomonaOboro, Haruna Martha M., Yisa Michal Awawu, Bids AlhajiAudu and Zaliya Ibrahim Waziri. (2019). Medically important parasites of *Clarias gariepinus* (catfish) in Nigeria. *Advances in Biotechnology and Microbiology*. Vol 15 issue 1.
- Ogbu, U. M., Okorafor, U. P., Unigwe, C. R. and Odah, S. I. (2019). Prevalence of common protozoan parasites of African catfish, *Clarias gariepinus* (Burchell, 1822) from three selected fish ponds in Ibadan North Local Government area, Oyo state, Nigeria. *Journal of Agriculture and Veterinary Science*. Vol 12: Issue 3 Ser III, pp 26-30.
- Okaeme, A.N. (1991). Helminthes fauna of the Tilapia of lake Kainji in pre and post impoundment condition. *Journal of Aquaculture Trop*, 6:1–8.
- Okoye, I.C., Abu Simon, J., ObiezueNdunwame, N.R., and Ofoezie, I.E. (2014). Prevalence and seasonality of parasites of fish in Agululake, southeast, Nigeria. *African Journal of Biotechnology*, Vol. 13 (3): 502 – 508pp.
- Omeji, S., Solomon, S.G. and Idoga, E.S. (2011). A comparative study of the common protozoan parasites of *Clarias gariepinus* from the wild and cultured environments in Benue State, Nigeria *Journal of Parasitology research*. Volume 2011: 8pp.
- Oniye S.J., Adebote D. A. and Ayanda O. I. (2004). Helminth parasites of *Clarias gariepinus* in Zaria, Nigeria. *J. Aquatic Sci*. 19 (2): 71-76.
- Poulin R. (2011). *The many roads to parasitism: A tale of convergence*. In D. Rollinson and S.I. Hay. Editors: *Advances in parasitology* Vol. 74. Burlington. Academic Press, 1 – 40pp.
- Roberts, L.S., Javony, J., and Schmidt, G.D. (2000) *Foundations of parasitology*. McGraw – Hill, Boston, Mass, USA. 6th edition international editions.
- Roberts, R. J. (1995). *Parasitology of teleosts in fish pathology*. London, UK, end edition.
- Roberts, R. J. (2001). *Fish pathology*, Elsevier Health Sciences, New York, NY. USA.
- Scholz, T., M.P.M. Vanhovey N. Smit., Z. Jayasundera and M. Gelna. (2018). *A guide to the parasites of African Freshwater fishes*. Vol. 18.
- Singh, J., Lindenstrom, T. and Buchmann, K. (2004). Expression of pro-inflammatory cytokines in rainbow trout (*Oncorhynchus mykiss*) during an infection with *Ichthyophthirius multifiliis*. *Fish and shellfish Immunology*. 1(17): 75-86
- Skelton, P.H. (2001). *A complete guide to the freshwater fishes of Southern African Capetown*: Struik Publishers, 235pp.
- Udechukwu C. U., Panda S. M., Sunday I. D. and Bello F. A. (2018). Parasites associated with *Clarias gariepinus* (African catfish) from dam, plastic and concrete ponds in Bauchi metropolis, Bauchi state, Nigeria. *GSC Biological and Pharmaceutical Sciences*. 02(02): 001-005.
- Ukoli, F.M.A. (1998). *Preliminary report of the helminthes infection of fish in the River Niger at Shagamu*. Ghana University Press, 269 – 285pp.
- Yagamuti, S. (1959). *Systema Helminthum*, Volume II. The cestodes of vertebrates. *Interscience Publishers, Inc*, New York, U.S.A. pp: 860.

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The Parasitic Fauna Prevalence of Gastrointestinal of *Clarias gariepinus* in Port Harcourt, Rivers State, Nigeria

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Abstract

Fish parasites are major constraint to production, sustainability and economic viability of aquaculture practice in Nigeria, but little has been documented on fish parasites and their associated risk factors. This study determined the prevalence of gastrointestinal parasites of *Clarias gariepinus*. A total 120 fishes of different age groups in lengths and weights and both sexes were randomly sampled from 3 fish farms (Station 1, Station 2 and Station 3) and examined for parasites. Out of the 120 fishes examined, 83 (69.10%) fishes were infected. Station 2 (33, 27.50%) recorded highest overall prevalence percentage parasitic fauna, followed by Station 1 (26, 21.60%) and Station 3 (24, 20%) the least. Sex-related prevalence of gastrointestinal parasites recorded highest in male (62, 51.59%) compared to female fishes (21, 16.0%). Age of fish based on lengths and weights indicated that smaller fishes harboured more parasites than bigger fishes. Observed parasites were nematodes, protozoan, trematodes and cestodes. Nematodes (33, 27.50%) recorded highest abundance. In conclusion, smaller fishes were heavily infected than bigger ones, this therefore suggests best management practice to mitigate parasitic infection should be focused on smaller fishes.

Keywords: Parasites, prevalence, alimentary canal, aquaculture, *Clarias gariepinus*, Port Harcourt

Introduction

Fish is an important source of food that supplies low cholesterol protein to approximately 60% of the world population (Sichewo *et al.* 2013). In most part of the world, fish production is mainly from the wild. As the world population grows, fish resources are being depleted at an increasing rate as a result of environmental degradation, over harvesting, pollution thus fish production could no longer meet the demand of the growing population. It has been reported that at least one parasite is hosted by approximately 50 to 90% of freshwater fishes (Eissa *et al.*, 2012). Losses resulting from these parasites are at high densities under existing conditions and, if left uncontrolled, may lead to catastrophic proportions (Abbas *et al.*, 2014). The normal growth of fish is affected by parasites that lives on the fish if highly infested.

Parasitism is most common and diverse in wild than in ponds, hatcheries and captivity. Infection in fishes occurs due to overcrowding and environmental stress. Intensification and expansion of fish culture is, however, facing severe threats from pathogens including parasites as they are one of the major causes for chronic mortalities and poor growth, affecting the yield and marketability of fishes. There is an increasing awareness of the importance of parasitic diseases as one of the major detrimental factors in fish farming (Keremah and Inko-Tariah, 2013). Fish parasites are a key constraint to the production, sustainability and economic viability of the aquaculture practice in Nigeria but little has been documented on fish parasites and their associated risk factors. This study therefore aimed at investigating the parasitic fauna affecting *C. gariepinus* in Port Harcourt with reference to some selected farms.

Materials and Methods

Study Area

The study was carried out within Port Harcourt, River State, Nigeria. The geographical location stretches between latitude 4° 45' N and 4° 60' N and longitude 6° 50' E and 8° 00' E (Figure 1). The area experiences an average rainfall of 2,500cm³ and temperature range of between 28 - 30°C annually which supports the rainforest type of vegetation.

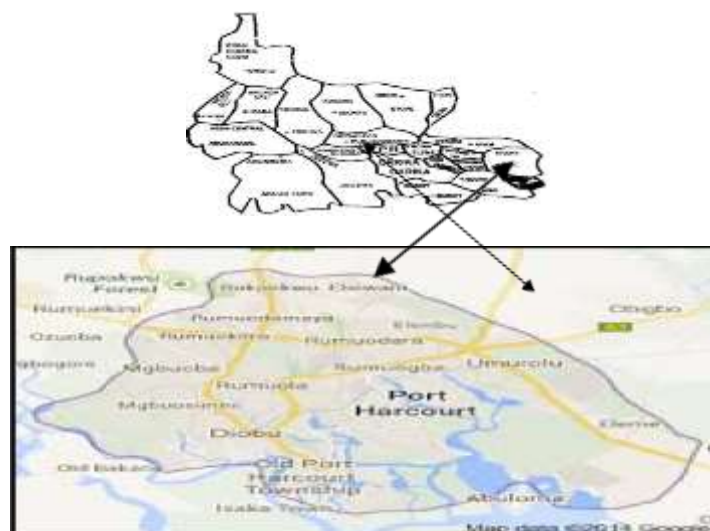


Figure 1: A map showing the site of samples locations and environ.

Sampling Collection and Procedure

A total of 120 live catfish were purchased from three fish farms in Port Harcourt. Samples of 40 each were randomly collected and carried in a 25 L plastic container for analysis in Fisheries Laboratory. The standard Lengths (SL) were determined using a calibrated ruler in cm and the weights measured (W) using Electronic weighing Scale, QE-KE-4. The sexes were identified by visual examination of urogenital system as described by Idodo-Umeh (2003).

Dissection and Examination

Fish sample were dissected through the abdomen using a surgical blade. The alimentary tract was isolated stretched out and grouped into esophagus, stomach and intestine. Sections were placed into three separate Petri dishes containing 5% saline and examined for parasites under a dissecting microscope. Parasites found were counted, fixed and preserved in 10% formalin.

Observation and Identification

Parasites taxa were used for identification, nematodes were cleared with lactophenol while the cestode and trematodes were stained with Ehrlich's haematoxylin solution, through series of alcohol (30, 50, 70, 90% and absolute) for 45 mins to dehydrate, cleared in methylsalicylate. The parasites were mounted on a glass slide and viewed under microscope. The observed parasites were identified as described by Chilton et al., 1995.

Statistical analysis

Data analysis was done on SPSS Statistics 23. Data were presented in tabulated and chart form while chi square test was used to compute and compare to arrive at statistical decision significantly at $p < 0.05$.

Results

Clarias gariepinus sampled out of the total 120 fish, 83 were found to be infected with an overall prevalence of 68.10%. Therefore, no significant difference in the overall prevalence of the samples examined (Table 1).

Table 1: Prevalence of gastrointestinal parasitic fauna t in Catfish (*Clarias gariepinus*)

Station	No Examined	No Infected	No not Infected	Prevalence (%)
Station 1	40	26	14	21.60
Station 2	40	33	7	27.50
Station 3	40	24	16	20.00
Total	120	83	37	69.10

Table 2: Prevalence rate among sexes of gastro-intestinal infection of *C.gariepinus*

Station	Male			Female		
	NE	NI	P (%)	NE	NI	P (%)
Station 1	26	17	14.16	14	9	6.00
Station 2	33	26	21.60	7	7	5.83
Station 3	35	19	15.83	5	5	4.16
Total	94	62	51.59	26	21	16.02

NE- Number examined, NI- Number infected, P- prevalence

Table 3: Prevalence Of Gastrointestinal Parasites Of *Clarias Gariepinus* Based On Age-Weight Range

Weight (g)	Station 1			Station 2			Station 3		
	NE	NI	P (%)	NE	NI	P (%)	NE	NI	P (%)
100 – 120	14	5	12.50	7	5	12.50	16	9	22.50
121 – 140	8	8	20.00	9	8	20.00	4	3	7.50
141 – 160	8	8	20.00	8	8	20.00	10	6	15.00
161 – 180	2	2	5.00	8	7	17.50	5	4	10.00
181 – 200	5	3	7.50	4	3	7.50	5	2	5.00
201 – 300	3	0	0	4	2	5.00	0	0	0.00
Total	40	26	65.00	40	33	82.50	40	24	60.00

Table 4: Length related prevalence of gastrointestinal parasites in *Clarias gariepinus*

Length cm	Station 1			Station 2			Station 3		
	NE	NI	P (%)	NE	NI	P (%)	NE	NI	P (%)
10-20	3	3	7.50	3	2	5.00	12	9	22.50
21-25	27	16	40.00	12	11	27.50	10	6	15.00
26-30	7	7	17.5	17	16	40.00	18	9	22.50
31-35	3	0	0	8	4	10.00	0	0	0
Total	40	26	65	40	33	82.50	40	24	60

Table 5: Overall prevalence of taxonomic groups of gastrointestinal parasites of *C. gariepinus*

Taxonomic group	Frequency	Prevalence (%)
Protozoan	25	20.83
Nematodes	33	27.50
Cestodes	12	10.00
Trematodes	13	10.83
Total	83	69.19

Discussion

The occurrence of these levels of gastrointestinal parasitism in the examined samples could also be hinged on the hygienic condition of the fish farms from which the fish were procured. Adequate hygiene is a necessity for the healthy aquaculture system. The highest prevalence of infection observed in Station 2, might have occurred due to poor fish environment, poor nutritional content and stress which can accelerate other infection leading to chronic disease. This is in line with Mdegela *et al.* (2011), who reported intestinal parasites prevalence of 25 (16.3%), attributed due to poor aquaculture practice and management. This finding is consistent with the report of Sikoki *et al.* (2013) and who reported overall prevalence rate at 42.70% and 60% respectively. In this present study the sex

related prevalence reveals 62 males (51.59%) compared with female fishes with a prevalence of 21 (16.02%). This may be attributed to vulnerability of males to infection. This finding agrees with the reports of Sinare *et al.* (2016) results showed no significant differences in abundance infection thus sexes having chances of infection. Males are always in movement, thus making them more vulnerable to infection but female observed less movement due to breeding production period and also difference in feeding rate.

The result revealed at juvenile stage highest infection level in gastrointestinal compared with the least observed at the adult stage. These correspond with Biu and Nkechi (2013) with prevalence percentage rate of 60.7% higher in juvenile in *Tilapia zilli* and also with Sani *et al.* (2019). Olorin and Somorin (2006), reported fish susceptibility corresponds with weight in its ability to resist or harbour the degree of infection, feeding diet at different stages of fish growth. The high prevalence of parasites in smaller fish observed may be attributed to vulnerability. The study also indicated that various parasitic fauna were recovered from the samples examined, from finding reports shown nematodes had the highest infection rate of prevalence percentage 69.19% in fish pond farms. Reports have shown that helminths are generally found in all freshwater fishes, with their prevalence and intensity dependent on factors of parasite species and their biology, host and its feeding habits, physical factors and hygiene of the water body, and presence of intermediate hosts where necessary (Hussen *et al.*, 2012). Aliyu and Solomon (2012) reported parasitic fauna are indicator of preference for region of attachment in the intestine, attributed to food availability and favourable conditions that enable the parasites to thrive. Similar observations by Owolabi, (2008), abundance of nematodes could be probably on the account for their preference for sites. The study has further shown that high rate prevalence of nematodes reveals it as the commonest infection of catfish in farms investigated. The presence of these parasites harbored in the fish and its occurrence could be due to failure in biosecurity practices managed in fish pond farms, such as poor management practices and poor nutrition thus, making the fish susceptibility higher.

References

- Abbass, F., Ashraf, M., Hafeez-Ur-Rehman, M., Iqbal, K.J., Abbas, S. & Javid, A. (2014). *Lernaea* susceptibility, infestation and its treatment in indigenous major and exotic Chinese carps under system. *Pakistan Journal Of Zoology* 46: 1215-1222.
- Biu, A. A., & Nkechi, O. P. (2013). Prevalence of gastrointestinal helminths of *Tilapia zilli* (Gervais 1848) in Maiduguri, Nigeria. *Nigerian Journal of Fisheries and Aquaculture*, 1(1), 20-24.
- Chilton, N.B., Gasser, R.B. & Beveridge, I. (1995). Difference in ribosomal DNA sequence of morphologically indistinguishable species within the *Hypodontus macrophi* complex (Nematoda: Strongyloidea). *International Journal of Parasitology*. 25(5): 647-651.
- Eissa, I., Zaki, V., Nadia, G & Zaki, M. (2012). Studies on prevailing cestodiasis in wild African catfish *Clarias gariepinus* at Kafr El-Sheikh governorate. *Life Science Journal* 9:506-511.
- Hussen, A., Tefera, M & Astrate, S. (2012). Gastrointestinal helminth parasites of *Clarias gariepinus* (Catfish) in Lake Hawassa Ethiopia. *Scientific Journal of Animal Science*. 1 (4): 131-136.
- Idodo-umeh, G. (2003). Fresh water fishes of Nigeria (Taxonomy, ecological notes, diets and utilization). ISBN 978-8052-01-0. 241 pp.
- Keremah, R.I.&Inko-Tariah, M.B. (2013). Comparative study of ectoparasites on Nile tilapia (*Oreochromis niloticus*) cultured under integrated and unintegrated pond systems. *African Journal of Biotechnology*, 12(19): 2711.
- Mdegela, R H, A N Omary, C Mathew and H E Nonga (2011), Effect of Pond Management on Prevalence of Intestinal Parasites in Nile Tilapia (*Oreochromis niloticus*) under Small Scale Fish Farming Systems in Morogoro, Tanzania. *Livestock Research for Rural Development*. Vol. 23 (6)
- Olurin, K. B., & Somorin, C. A. (2006). Intestinal helminths of the fishes of Owa stream, south-western Nigeria. *Research Journal of Fisheries and Hydrobiology*, 1, 6-9.
- Owolabi, O.D. (2008). Endoparasitic helminthes of the Upside-down Catfish, *Synodontis membranaceus* (Geoffrey saint Hilarie) in Jebba Lake, Nigeria. *International Journal of Zoological Research*, 4(3): 15-173.
- Sichewo, P.R., Gono, R.K., Muzondiwa, J.V. & Nyoni, S. (2013). Isolation and Identification of Pathogenic Bacteria in Edible Fish: A Case Study of Fletcher Dam in Gweru, Zimbabwe. *IJSR* Vol.2:ISS 9,pp 269.
- Sikoki Francis, Sidney Nzeako, Betty Nchege (2013), Evaluation of Nematode Parasitemia in *Oreochromis niloticus* from Lower New Calabar River, Port Harcourt, Niger Delta, Nigeria. *International Journal of Scientific Research in Environmental Sciences (IJSRES)*, 1(10), pp. 263-267
- Sinaré Yamba Magloire, Bounou, Adama Ouéda, Awa Gnémé and Gustave B. Kabré (2016), Diversity and seasonal distribution of parasites of *Oreochromis niloticus* in semi-arid reservoirs (West Africa, Burkina Faso). *African Journal of Agricultural Research*, Vol. 11(13), pp. 1164-117

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Potential and Prospects of Herbal Application in Aquaculture

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Abstract

Aquaculture is one of the major sources of fish supply all over the world. The fast development of aquaculture and increasing fish demand has resulted in intensification of fish culture, amplifying the incidence of stressors in cultured fish and thus heightening the risk of disease. Until now, chemotherapy has been widely used to prevent and treat disease outbreaks during aquaculture operations. The use of chemical drugs has been reported to have manifold damaging impacts on the fish, environment and human health e.g. resistant bacterial strains and residual accumulation in fish tissue. Consequently, disease management in aquaculture now focus on environmentally friendly methods of treatment. Recently, increasing attention is being paid to the use of plant products for disease control in aquaculture as an alternative to chemical treatments. Plants have been reported to have the potential to cure many diseases, promote growth, reduce stress, improve immunity and prevent infections in fish under culture. Hence, their use during aquaculture is becoming more popular. They are better than various antibiotics and vaccines used in the treatment of diseases. The present paper highlights the importance of herbs and herbal products in aquaculture and their applications for sustainable fish production.

Keywords: Aquaculture, Herbs, Disease, Growth, Immunostimulant

Introduction

Aquaculture is a rapidly growing economic sector and has been reported as the fastest growing food producing industry all over the world (Ali *et al.*, 2017). To meet the growing global population and human requirements, this sector has grown by 6.2 percent on average over the last 30 years (Acaret *et al.*, 2015). In practice, intensive and semi-intensive aquaculture production has resulted in a rise in disease outbreaks, with partial or complete loss of fish in the culture medium (Bilenet *et al.*, 2016). Disease attacks in fish are caused by a variety of circumstances. Overcrowding in a location, irresponsible handling, poor water quality (pH, temperature, dissolved oxygen levels, ammonia levels, water turbidity, etc.), the presence of pollutants, and poor nutritional conditions are only a few examples. Immunosuppression occurs in fish as a result of these circumstances, making them more susceptible to infectious diseases (Gabriel, 2019). As a result, alternative sustainable strategies followed by substitutes for antibiotics, vaccines, or other chemical therapeutics, are highly needed that are characterized as immunostimulants by a broad-spectrum activity, which contribute to fish growth mechanism, and more precisely, cost-effective, eco-compatible best quality products from aquaculture indeed (Gabriel, 2019). Over the past two decades, it has been a common trend of using plant-derived supplements rather than chemical residues in aquaculture because of many factors: low cost, ready availability, fewer side effects in fish health and sustainable practice for aquatic environments (Reverter *et al.*, 2014; Van Hai, 2015; Gabriel, 2019).

Many studies show that inclusion of herbs in fish diet has positive effect on growth and disease free fishes. Excess use of various antibiotics, hormones and other synthetic drugs to control diseases and improve fish growth in aquaculture is the reason behind the emergence of drug resistant bacteria and production of toxic substances harmful to the environment and human health and suppress immunity in the host (Wu *et al.*, 2010). Utilization of herbs is being described as cheaper, eco-friendly with minimum side effects are used as alternative to antibiotics in fish health management. World Health Organization (WHO) encourages supplemented diets incorporated with medicinal herbs or a plant which minimizes the use of chemicals in fish diet. In this context herbs and herbal products can be used in fish diet to increase feed consumption in fish under culture (Wu *et al.*, 2016). This review is carried out to focus on the beneficial actions of different medicinal plants in aquaculture. Most specifically, how medicinal plant products modulate the immune response of the fish body.

Applications of Medicinal Plants in Aquaculture

Medicinal or therapeutic plants are widely used in underdeveloped countries, the reason being that they are relatively easy to obtain, available almost everywhere, and cheaper than modern medicines (Ahmad *et al.*, 2011).

The use of traditional medicine in many countries has almost no regulations. However, the World Health Organization has always encouraged these countries to develop regulations for the safe use of their traditional medicines. Some species of medicinal plants face ecological pressures, such as habitat destruction, and the particular threat of over-collection to meet market demands (Wei et al., 2009). The use of medicinal plants are not only intended for humans, but also for the benefit of livestock such as; cows, pigs, buffalo, sheep, goats, horses, chickens and others. Fisheries are also not left behind. Several species of plants have long been given specifically to fish that are attacked by diseases, increase appetite and increase fish endurance. Traditionally, people were strongly dependant on medicinal plants to prevent and treat diseases (Tsabang et al., 2016). Several parts of medicinal plants like leaves, roots, rhizome, bark, bulbs, as well as seeds have been used as crude or extracting active compounds (Zhang et al., 2014). They are recorded for a diverse range of biological activities such as: modulation of the immune response, growth promotion, antioxidant enhancing, antistress, digestion-stimulating, and gastro protective effects (Gabriel et al., 2015). Moreover, drug resistance features was rarely diagnosed in fish body systems due to diversity in molecular extracts of medicinal plants, which are biodegradable compared to synthetic drugs (Reverter et al., 2014). Application of medicinal plants in fish farming is mainly done by three established methods such as: oral administration, immersion or bathing, and injection (Reverter et al., 2014;). The oral application is the most common, economically suitable technique and less stressful for fish of any size, but least effective due to slow absorbance (Bulfon et al., 2015). Immersion is more useful for a small fish size population (weight < 15 gm) and could be expensive as it requires a large amount of solution preparation (Awad&Awaad, 2017).

Roles of Medicinal Plants in Aquaculture

Application of herbs in aquaculture have been reported to play different roles, some of which are highlighted below:

1. Promote the Growth of Fish in the Culture Medium

Generally, application of herbs has been reported to promote the growth of fish in the culture medium. This can be achieved because medicinal plants increase the digestive enzyme secretion, which leads to growth promotion and enhances an increase in the survival rate of fish (Van Hai, 2015). This suggestion was supported by Shalaby et al., (2006) who observed that crude extracts of *Allium sativum* increased WG, SGR, and feed intake of the Nile tilapia (*Oreochromis niloticus*) as well. Crude powder of caraway showed a significant impact as a growth promoter for the Nile tilapia (Abdel-Tawwab et al., 2018).

2. Boost the Immunity of Fish

Fish exposed to medicinal plants containing bioactive compounds, which act as immunostimulants, have been reported to boost both the specific and the non-specific immune response (Ghosh et al., 2018). Since the immune system is a biological mechanism of protecting living organisms from pathogens, medicinal plants can boost up the immune responses of fish, which eventually increase their antipathogenic capability (Bulfon et al., 2015).

3. It helps in treatment of Fish Disease

Herbal plants contain a considerable amount of antimicrobial substances potentially utilised as herbal medications to fight a wide range of pathogenic microbes. Different plants contain considerable bioactive compounds, including steroids, proteins, tannins, saponins, terpenoids and alkaloids. These phenolic compounds are proven to resist against a range of bacteria pathogens (*Salmonella typhi*, *Bordetella pertussis*, *Corynebacterium parvum*, *Klebsiella pneumoniae*, *Mycobacterium* and *Escherichia coli*), fungi (*Aspergillus flavus*, *Aspergillus fumigatus*, *Fusarium solani* and *Pseudomonas aeruginosa*) and viruses (retrovirus, simian-virus) (Talpure et al., 2014).

4. Prevent Fish Disease

In response to the overall adverse effect of resistant antimicrobial drugs in aquaculture through a direct effect on fish health and aquatic habitat and indirectly on human health, medicinal plants are suggested to be a promising alternative to prevent fish disease. The application of medicinal plants in aquaculture is not limited to only chemotherapeutics but also could be used as feed additives, since the latter contains a considerable amount of functional nutrients and bioactive compounds. (Punitha et al., 2008).

5. Creates an Eco-friendly Environment

In aquaculture system, usage of antibiotics, pesticides and insecticides causing another problem of drug resistance in pathogen (Reverter, 2014; Caipang, 2015). Additionally, bioaccumulation is also a problem which ultimately affects human health. The use of these chemicals directly or indirectly affects the non-target organisms. Therefore, the compounds that are derived from medicinal plants are an alternative approach against these pathogens. They have no negative impact on environment as they are biodegradable.

Conclusion

In conclusion, this paper reveals the importance of medicinal plants in different aquaculture operations as growth promoters, immunostimulants and alternatives to antibiotics, or chemotherapeutic agents. By examining the problem of antibiotic resistance against pathogen, medicinal plants is an excellent approach in treating parasitic, bacterial and viral infections in fishes. The major area of research is to estimate mode of preparation, dosage application, duration of treatment and also effect on other fish species. From this study we conclude that: However various medicinal have the potential as growth promoter and immune-stimulant but only few shows the effect on fish health like histological parameters. . For the sustainability of the expanding fish industry, it is vital to find a more feasible and well-developed protocol for using medicinal plants in aquaculture. For the large-scale fish industries, commercially produced medicinal plants are highly recommended for utilization.

References

- Abdel-Tawwab, M.; Samir, F.; Abd El-Naby, A.S. and Monier, M.N. (2018a).Antioxidative and immunostimulatory effect of dietary cinnamon nanoparticles on the performance of Nile tilapia, *Oreochromis niloticus* (L.) and its susceptibility to hypoxia stress and *Aeromonashydrophila* infection. *Fish.Shellfish.Immunol.*, 74: 19-25.
- Abdel-Tawwab, M.; Adeshina, I.; Jenyo-Oni, A.; Ajani, E.K. and Emikpe, B.O. (2018b). Growth, physiological, antioxidants, and immune response of African catfish, *Clarias gariepinus* (B.), to dietary clove basil, *Ocimum gratissimum*, leaf extract and its susceptibility to *Listeria monocytogenes* infection. *Fish.Shellfish.Immunol.*, 78: 346-354.
- Acar, Ü. (2018). Effects of diet supplemented with ethanolic extract of propolis on growth performance, hematological and serum biochemical parameters and disease resistance of Mozambique tilapia (*Oreochromis mossambicus*) against *Streptococcus iniae*. *Aquac.*, 495: 339-344.
- Acar, Ü.; Kesbiç, O.S.; Yılmaz, S.; Gültepe, N. and Türker, A. (2015). Evaluation of the effects of essential oil extracted from sweet orange peel (*Citrus sinensis*) on growth rate of tilapia (*Oreochromis mossambicus*) and possible disease resistance against *Streptococcus iniae*. *Aquac.*, 437: 282-286.
- Ahmad, M.H.; El Mesallamy, A.M.D.; Samir, F. and Zahran, F. (2011).Effect of cinnamon (*Cinnamomum zeylanicum*) on growth performance, feed utilization, whole-body composition, and resistance to *Aeromonashydrophila* in Nile Tilapia. *J. Appl. Aquac.*, 23: 289-298.
- Ali, M.; Soltanian, S.; Akbary, P. and Gholamhosseini, A. (2017). Growth performance and lysozyme activity of rainbow trout fingerlings fed with vitamin E and selenium, marjoram (*Origanum* spp.), and ajwain (*Trachyspermum ammi*) extracts. *J. Appl. Anim. Res.*, 46: 650-660.
- Awad, E. and Awaad, A. (2017).Role of medicinal plants on growth performance and immune status in fish.*Fish.Shellfish.Immunol.*, 67: 40-54.
- Bilen, S.; Altunoglu, Y.C.; Ulu, F. and Biswas, G. (2016). Innate immune and growth promoting responses to caper (*Capparis spinosa*) extract in rainbow trout (*Oncorhynchus mykiss*). *Fish.Shellfish.Immunol.*, 57: 206-212.
- Bulfon, C.; Volpatti, D. and Galeotti, M. (2015).Current research on the use of plantderived products in farmed fish.*Aquac. Res.*, 46: 513-551.
- Gabriel, N.N.; Qiang, J.; Ma, X.Y.; He, J.; Xu, P. and Liu, K. (2015). Dietary Aloe vera improves plasma lipid profile, antioxidant, and hepatoprotective enzyme activities in GIFT-tilapia (*Oreochromis niloticus*) after *Streptococcus iniae* challenge. *Fish Physiol. Biochem.*, 41: 1321–1332.
- Gabriel, N.N. (2019). Review on the progress in the role of herbal extracts in tilapia culture. *Cogent Food Agri.*, 5: 1619651.
- Ghosh, K., Ray, A.K. and Ringø, E. (2018). Applications of plant ingredients for tropical and subtropical freshwater finfish: possibilities and challenges. *Rev. Aquac.*, 11: 793-815.
- Punitha, S.M.J.; Babu, M.M.; Sivaram, V.; Shankar, V.S.; Dhas, S.A.; Mahesh, T.C.; Immanuel, G. and Citarasu, T. (2008).Immunostimulating influence of herbal biomedicines on nonspecific immunity in Grouper *Epinephelus tauvina* juvenile against *Vibrio harveyi* infection.*Aquac. Int.*, 16: 511–523.
- Reverter, M.; Bontemps, N.; Lecchini, D.; Banaigs, B. and Sasal, P. (2014). Use of plant extracts in fish aquaculture as an alternative to chemotherapy: current status and future perspectives. *Aquac.*, 433: 50- 61.
- Shalaby, A.M.; Khattab, Y.A. and Abdel Rahman, A.M. (2006).Effects of Garlic (*Allium sativum*) and chloramphenicol on growth performance, physiological parameters and survival of Nile tilapia (*Oreochromis niloticus*). *J. Venom. Anim. Toxins. Incl. Trop. Dis.*, 12(2): 172-201.
- Talpur, A.D. (2014). *Menthapiperita* (Peppermint) as feed additive enhanced growth performance, survival, immune response and disease resistance of Asian seabass, *Lateolabrax japonicus* (Bloch) against *Vibrio harveyi* infection. *Aquac.*, 420-421: 71-78.

- Tsabang, N.; Ngah, N.; Estella, F.T. and Agbor, G.A. (2016). Herbal medicine and treatment of diabetes in Africa: Case study in Cameroon. *Diab. Case Rep.*, 1(112): 2.
- Van Hai, N. (2015). The use of medicinal plants as immunostimulants in aquaculture: A review. *Aquac.*, 446: 88-96.
- Watts, J.E.M.; Schreier, H.J.; Lanska, L. and Hale, M.S. (2017) The rising tide of antimicrobial resistance in aquaculture: sources, sinks and solutions. *Mar. Drugs.*, 15(6):158
- Wei, L.; Sun, B.; Chang, M.; Liu, Y. and Nie, P. (2009). Effects of cyanobacterial toxin microcystin-LR on the transcription levels of immune-related genes in grass carp *Ctenopharyngodonidella*. *Environ. Biol. Fish.*, 85: 231.
- Wu, C.C.; Liu, C.H.; Chang, Y.P. and Hsieh, S.L. (2010). Effects of hot-water extract of *Toonasinensis* on immune response and resistance to *Aeromonashydrophila* in *Oreochromismossambicus*. *Fish.Shellfish.Immunol.*, 29: 258-263.
- Wu, Y.S.; Chen, Y.Y.; Ueng, P.S. and Nan, F.H. (2016). Effects of medicinal herbs "Plantagoasiatica", "Houttuyniacordata" and "Menthahaplocalyx" on nonspecific immune responses of cobia (*Rachycentroncanadum*). *Fish.Shellfish.Immunol.*, 58: 406-414.
- Zhang, X.P.; Li, W.X.; Ai, T.S.; Zou, H.; Wu, S.G. and Wang, G.T. (2014). The efficacy of four common anthelmintic drugs and traditional Chinese medicinal plant extracts to control *Dactylogyrusvastator* (Monogenea). *Aquac.*, 420: 302- 307.

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Comparative Study of Harvested Surface Water and Ground Water for Aquaculture Usage in Imo State

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Abstract

Comparative study Surface Water and Ground water was carried out in the three agricultural zones of Imo State. Water samples were collected from the different locations, and analysed for some physico-chemical parameters (Temperature, Dissolved Oxygen, pH, Total dissolved solids, Conductivity, Hardness and Chlorine using standard methods. Results obtained from the study showed that the physico-chemical parameters of surface water and ground were not significantly different ($P < 0.05$) except Conductivity which was higher in underground water. However, the water parameters tested were within the normal limit. Surface water temperature (26.55 ± 0.55 - $26.93 \pm 0.75^\circ\text{C}$), pH (6.63 ± 0.15 - 6.96 ± 0.11), Dissolved oxygen (6.6 ± 0.1 - 6.9 ± 0.5 mg/l), Total dissolved solid (35.0 ± 1.0 - 37.3 ± 1.1 mg/l), Conductivity (13.3 ± 0.57 - 15.0 ± 1.0 µSm⁻¹), Hardness ($45.10 \pm 45.5 \pm 0.89$ mg/l), Chlorine (7.10 ± 0.45 - 8.1 ± 0.34), Ground water temperature (26.78 ± 0.57 - 30.3 ± 0.85), pH (6.83 ± 0.3 - 7.23 ± 0.5), Dissolved oxygen (5.33 ± 0.3 - 6.8 ± 0.2 mg/l), Total dissolved solids (24.3 ± 0.57 - 35.0 ± 1.0 mg/l), Conductivity (13.3 ± 0.57 - 23.6 ± 1.56 µSm⁻¹), Hardness (35.6 ± 0.26 - 48.6 ± 3.1 mg/l), Chlorine (8.1 ± 0.4 - 12.53 ± 0.88) for aquaculture and can be used for the purpose. It is therefore recommended that fish farmers can utilize both underground water and surface water to grow fish in these different locations.

Keywords: Surface water, Ground water, physico-chemical parameters, fish production, Agricultural zones

Introduction

Aquaculture is a process of growing any aquatic animals for subsistence use or for commercial purposes. It involves feeding, harvesting and many other processes. Aquaculture development world wide is growing rapidly due to increasing demand for its products and limited production potential from inland and marine capture fisheries. Water is the most important element for aquaculture production therefore site selection must consider the water source and suitability. (Ogeibu and Egborge, 1995). There are two main categories of water supply for aquaculture purposes, ground and surface water (Arabi, *et.al*, 2011). Underground or Ground water often differs substantially from surface water in their characteristics. For aquaculture, most farmers usually consider underground water because of its consistency in quality and quantity (Arabi, *et.al*, 2011).

Many authors over the years have classified Water harvesting in a number of ways. However, the large majority of definitions are related closely. Water harvesting can be defined as "the gathering and the management of rainwater run-off, flood water in order to sustainably increase availability of water for agricultural and domestic use as well as ecosystem sustenance. (Aniebone *et al*, 2014). In Nigeria and the sub sahara Africa, the major sources of water for fish farmers include: tap water, water from streams/ rivers, underground water such as well boreholes and harvested water from rainfall and flooding. One of the greatest challenges encountered by fish farmers in Nigeria have to do with pollution from industrial activities, mining and the petroleum industries. (Aniebone *et al*, 2014). Water pollution is a global problem considering that water is very essential to living organisms. Water is required for aquaculture production and also the organisms that it harbours (Olowosegun *et al.*, 2005). Ugwumba and Chukwuji (2010) in their study reported that mortality of fish due to disease and water pollution constitutes problems to aquaculture development in the country. Pollution of surface water has recorded severe impacts on fisheries production. Poor water quality may affect fish and shellfish health and may impair their development, (Onuoha, 2009). Hence this study was carried out to assess the quality of harvested surface water and ground water for aquaculture usage in Imo State.

Materials and Methods

Study Area: The three agricultural zones in Imo state namely Okigwe (Location 1), Orlu (Location 2) and Owerri (Location 3) were selected for this study.

Collection of samples:

Three water samples each of underground and harvested water were collected for the study with the aid of a water container. They were examined and determined. Analysis of physico-chemical parameters: The following parameters were investigated-Temperature, pH, Dissolved Oxygen, Total dissolved solids, Conductivity, hardness and chlorine. They are were analysed in-situ and in the laboratory using the method described by (APHA) 1998 and cited in Onuoha 2009.

Statistical Analysis: The results obtained were subjected to statistical analysis using ANOVA and the means were separated using the Duncan Multiple Range Test (DMRT).

Results

The surface water temperature for the water samples recorded during the study period was within the range of $26.55 \pm 0.55^{\circ}\text{C}$ - $26.93 \pm 0.75^{\circ}\text{C}$ for harvested surface water, $29.83 \pm 0.57^{\circ}\text{C}$ - $30.8 \pm 0.72^{\circ}\text{C}$ for underground water. with a mean of 28.18 ± 1.87 at location 1, 28.6 ± 1.9 at location 2 and 28.8 ± 2.21 at location 3. The highest temperature of $30.8 \pm 0.72^{\circ}\text{C}$ was recorded at location 3 from the underground water sample while the least was $26.55 \pm 0.55^{\circ}\text{C}$ recorded at location 1 from the harvested surface water sample (Table 1). The pH values for the different water samples from the different locations during the study period are also shown in Table 1. The pH values varied between 6.63 ± 0.15 and 6.96 ± 0.11 for harvested surface water sample, 7.06 ± 0.45 - 7.23 ± 0.5 for underground water samples with a mean of 6.91 ± 0.33 at location 1, 7.1 ± 0.16 at location 2 and 6.91 ± 0.33 at location 3. The highest pH value of 7.23 ± 0.5 was recorded from underground water sample at location 2 while the lowest value of 6.63 ± 0.15 was recorded from harvested surface water at location 1 during the study period. The result for the dissolved oxygen concentration measured for each location for the water samples collected during the period of study was also presented which was within the range $5.3 \pm 0.33 \text{mg/l}$ and $5.8 \pm 0.25 \text{mg/l}$ recorded from underground water sample, $6.6 \pm 0.1 \text{mg/l}$ - 6.9 ± 0.50 recorded from harvested surface water samples with a mean of $6.17 \pm 0.94 \text{mg/l}$ in location 1, $6.23 \pm 0.43 \text{mg/l}$ in location 2 and $6.36 \pm 0.58 \text{mg/l}$ in location 3. The highest concentration of dissolved oxygen value of $6.9 \pm 0.50 \text{mg/l}$ was observed in harvested surface water samples at location 2 while the least value of $5.3 \pm 0.33 \text{mg/l}$ was recorded in location 2 from underground water sample.

The concentrations obtained in this study shows that the water samples contains normal concentrations of dissolved oxygen. The results of the total dissolved solids concentration of the water samples are presented in the three tables. Total dissolved solids have to do with the amount of inorganic particles present in water. Concentrations of water parameters measured on location by location basis on the water samples during the study period ranges from $24.3 \pm 0.57 \text{mg/l}$ - $25.6 \pm 0.57 \text{mg/l}$ for underground water samples, $35.0 \pm 1.0 \text{mg/l}$ - 37.3 ± 1.1 with an overall mean of $30.46 \pm 5.64 \text{mg/l}$ in location 1, $30.83 \pm 7.1 \text{mg/l}$ in location 2 and $30.3 \pm 5.16 \text{mg/l}$. The lowest concentration of 24.3 ± 0.57 was recorded in location 2 from underground water sample with the highest concentration of $37.3 \pm 1.1 \text{mg/l}$ was recorded at station 2 from harvested surface water. Water hardness recorded ranges between $45.0 \pm 1.0 \text{mg/l}$ - $45.3 \pm 0.32 \text{mg/l}$ for harvested surface water, $35.6 \pm 0.26 \text{mg/l}$ - $51.9 \pm 3.0 \text{mg/l}$ for underground water sample with an overall mean of $46.81 \pm 2.8 \text{mg/l}$ at location 1, $40.6 \pm 17.4 \text{mg/l}$ at location 2 and 48.6 ± 4.01 at location 3. The least concentration value of $35.6 \pm 0.26 \text{mg/l}$ was recorded in location 2 from underground water sample. On the other hand, the highest concentration value of $51.9 \pm 3.0 \text{mg/l}$ was recorded in location 3 from underground water sample (Table 2). Results of the Chlorine values measured in the three locations from harvested surface water and underground water are presented in the table. Chlorine had a range from $7.0 \pm 0.45 \text{mg/l}$ to $8.1 \pm 0.34 \text{mg/l}$ for harvested surface water, 12.53 ± 0.55 to 12.8 ± 1.04 with a mean of 10.36 ± 0.2 in location 1, 9.7 ± 3.06 in location 2 and 10.38 ± 2.5 in location 3. The minimum value of $7.0 \pm 0.45 \text{mg/l}$ was observed at location 1 from harvested surface water sample. The highest value of $12.8 \pm 1.04 \text{mg/l}$ was observed at location 1 from ground water sample. Table 3 and Table 4 show the mean and significant difference in the results of the water analysis conducted, temperature values ($30.33 \pm 0.21^{\circ}\text{C}$ ground water, $26.78 \pm 0.23^{\circ}\text{C}$ harvested surface water) pH, (7.16 ± 0.8 groundwater, 6.81 ± 0.8 surface water), Dissolved oxygen, ($5.70 \pm 0.1 \text{mg/l}$ ground water, $6.81 \pm 0.10 \text{mg/l}$ surface water), Total dissolved solids, ($25.11 \pm 0.25 \text{mg/l}$ ground water, $35.9 \pm 0.25 \text{mg/l}$ surface water) conductivity ($21.88 \pm 0.32 \mu\text{Sm}^{-1}$. ground water, $14.2 \pm 0.3 \mu\text{Sm}^{-1}$. surface water and chlorine ($12.6 \pm 2.0 \text{mg/l}$ ground water, $7.60 \pm 0.2 \text{mg/l}$ surface water) were significant ($p < 0.05$). Hardness showed no significant difference ($p > 0.05$) between ground water ($45.41 \pm 3.6 \text{mg/l}$) and harvested surface water (45.3 ± 3.61).

Discussion

Temperature has a profound effect on chemical and biological processes going on in water and tropical fishes are known to grow best in temperatures between 23.0°C - 32°C (Ajana et al., 2006). Temperature affects the development and growth of fish more than any other single factor. Each species has optimal growth and reproduction temperature ranges. Onuoha, 2009 Most species in Nigeria are tropical in origin which indicates that the water samples analysed is suitable for aquaculture purposes. This result corroborates with the findings of (Aniebone, et al. 2014) which ranges from (26.55±0.55-26.93±0.75°C). The dissolved oxygen concentrations quoted in this study shows that both underground water and harvested surface water contain normal concentrations of dissolved oxygen (Ajana et al, 2006). Anyanwu (1988) reported that in fish ponds, only small fishes can survive when exposed for a short time to dissolved oxygen concentrations of 0.0 – 0.3 mg/l. Dissolved oxygen sensitivity of freshwater invertebrates commonly reflect the habitats in which they live. In aquatic environments, the respiratory rate usually will depend on the oxygen concentration, and this rate may decline sharply at low-to mid-saturation levels. The pH values obtained (7.16±0.8 groundwater, 6.81±0.8 surface water) are well within the preferred pH range of 6.5 – 9.0 for optimum fish production as reported by Onuoha, 2009). McCulloch (1990). studied the metabolic response of the grass shrimp *Palaemonetes kadiakensis* to sublethal changes in pH in Texas near the Gulf of Mexico. He observed that pH had an effect on critical oxygen concentration, which was significantly higher at a pH of 6.5 than the control (7.8), and significantly lower at a pH of 9.0 than the control. Total dissolved solids have to do with the amount of inorganic particles present in water. such as, bicarbonate, Sulphate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. These ions are important in sustaining aquatic life. The trend of changing concentration of total dissolved solid (TDS) with season is in agreement with the findings of Diaz et al., (2000) who stated that the composition of harvested surface water cannot be expected to be constant over a length of time. The total dissolved solids recorded during the study period all fell within the normal range (<400mg/l) for aquaculture. (25.11±0.25mg/l ground water, 35.9±0.25mg/l surface water) On the other hand includes those materials dissolved in the water, such as, bicarbonate, Sulphate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. These ions are important in sustaining aquatic life.

The conductivity value recorded in this study is normal for aquaculture (21.88±0.32 μSm^{-1} . ground water, 14.2±0.3 μSm^{-1} . surface water and this is in line with Egborge, (1994), who classified waters with conductivity values below 100 μSm^{-1} as fresh, those above 1000 μSm^{-1} as marine while those in between are brackish. Water hardness is important to fish culture and a commonly reported aspect of water quality. Water hardness is important to fish culture and a commonly reported aspect of water quality. It is a measure of the quantity of divalent ions such as calcium, magnesium and/or iron in water (William, 2004). It is a measure of the quantity of divalent ions such as calcium, magnesium and/or iron in water (William, 2004). The water hardness in the sampling locations all fell within the recommended range for fish culture, ground water (45.41±3.6 mg/l) and harvested surface water (45.3±3.61). According to Bhatnagar and Devi. (2013), hardness values less than 20mg/l causes stress, 75-150 mg/l is optimum for fish culture and >300 ppm is lethal to fish life as it increases pH, resulting in non-availability of nutrients. According to Stone and Thomforde (2004), the desirable range of chlorides for commercial catfish production is above 60 mg l⁻¹ and acceptable range is 10 times the nitrite concentration. It becomes a matter of concern if chloride levels become high as above 100 mg L⁻¹ in the waters because even in very small concentrations, it burns the edges of the gills with long term after effects and its acceptable range is 0. This indicates that the value of chlorine concentration (12.6±2.0 mg/l ground water, 7.60±0.2mg/l surface water) obtained during this study falls within the normal range for fish culture. Chloride and chloramine as low as 4mg/l of hypochlorite can be harmful to fish within four days of exposure (Alabaster and Loyd, 1980).

Table 1: Results of Harvested Surface Water in the study area

Parameters	Location 1	Location 2	Location 3
Temp (°C)	28.18±1.87 ^a	28.6±1.9 ^a	28.8±2.21 ^a
pH	6.91±0.33 ^a	7.1±0.16 ^a	6.95±0.36 ^a
DO (mg/l)	6.17±0.94 ^a	6.23±0.43 ^a	6.36±0.58 ^a
TDS(mg/l)	30.46±5.64 ^a	30.83±7.1 ^a	30.3±5.16 ^a
COND(μSm^{-1} .)	16.5±2.5 ^a	19.3±4.8 ^b	18.3±5.5 ^b
Hardness(mg/l)	46.81±2.8 ^a	40.6±17.4 ^a	48.6±4.01 ^a
Cl (mg/l)	10.36±0.2 ^a	9.7±3.06 ^a	10.38±2.5 ^a

Table 2: Results of Ground Water in the study area

Parameters	Location 1	Location 2	Location 3
Temp (°C)	26.78±0.57	29.83±0.57	30.3±0.85
pH	6.83±0.3	7.2±0.10	7.23±0.5
DO (mg/l)	6.8±0.2	5.3±0.33	5.8±0.25
TDS(mg/l)	35.0±1.0	25.3±0.57	24.3±0.57
COND(μSm^{-1} .)	13.3±0.57	18.6±1.15	23.6±1.52
Hardness(mg/l)	45.3±0.32	48.6±3.1	35.6±0.26
Cl (mg/l)	8.1±0.34	12.8±1.04	12.53±0.55

Table 3: Mean Differences in the locations

Parameters	Ground water	Surface water	Significance
Temp (°C)	30.33±0.21	26.78±0.23	0.00
pH	7.16±0.8	6.81±0.8	0.09
DO (mg/l)	5.70±0.1	6.81±0.10	0.00
TDS(mg/l)	25.11±0.25	35.9±0.25	0.00
COND(μSm^{-1} .)	21.88±0.32	14.2±0.3	0.98
Hardness(mg/l)	45.41±3.6	45.3±3.61	0.00
Cl (mg/l)	12.6±2.0	7.60±0.2	0.00

Table 4: Table showing the significant difference between Ground water and Surface water

Parameters	Location 1	Location 2	Location 3
Temp (°C)	26.55±0.55	26.93±0.75	26.78±0.57
Ph	6.63±0.15	6.96±0.11	6.83±0.3
DO (mg/l)	6.9±0.50	6.6±0.1	6.8±0.2
TDS(mg/l)	35.6±0.52	37.3±1.1	35.0±1.0
COND(μSm^{-1} .)	14.3±0.51	15.0±1.0	13.3±0.57
Hardness(mg/l)	45.0±1.0	45.5±0.89	45.3±0.32
Cl (mg/l)	7.9±0.51	7.0±0.45	8.1±0.34

Conclusion and Recommendations

This study has provided valuable information on both harvested surface water and underground water in Imo State with respect to their suitability for fish farming. Generally, the water samples have relatively good qualities for aquaculture production. The water quality for harvested surface and ground water from the sources at different geographical locations varied considerably but the values fall within acceptable limits for aquaculture purposes. We hereby recommend that fish farmers in the area should adopt the system of using any of the water sources—harvested surface water or underground water for fish production to ensure sustainability in production.

References

- Aniebone, V.O, Ebonwu, V.I and Ezekwe, C.D, (2014). Assessment of surface and ground water in some parts of Enugu state, Nigeria for aquaculture use. *Proceedings of the 29th annual conference of the Fisheries Society of Nigeria, Makurdi 2014*. Pp 286-290.
- Anyanwu, P.E. (1998): Water quality management in fish ponds. *DIFFRI/NIOMR organized Aquaculture workshop at Ibadan Abeokuta*. Aquaculture research division, NIOMR, Victoria Island Lagos.
- Ajana, A.M, Adekoya B.B, Olunuga, O.A, and Ayansawo, T.O (2006). *Practical Fish farming*. Alliance for community transformation publishers.
- Alabaster, J.S and Lloyd, R (1980): *Water Quality Criteria for Freshwater Fish*. – 297 pp. London-Boston: Butterworth 1980.
- American Public Health Association (APHA) (1998): *Standard methods for the examination of water and waste water*. 20th edition. Washington D.C. 1161pp.
- Arabi, A., Oweis, T., Rashid, M., El Nagggar, S. and A. Ali. (2011). Water harvesting options in the drylands at different spatial scales. *Land Use and Water Resources Research* 7:1-13.

- Bhartnagar A, and Devi, P (2013). Water Quality guidelines for management of fish ponds. *International Journal of Environmental sciences* Volume 3 issue 6. pp?
- Diaz, I.S, Roa, A, Garcia, C.B, Acero, A and Navas, G, (2000): Length - weight relationships of demersal fish from upper continental slope off Columbia. *The ICLARM quarterly*, 23 (2) 23-25.
- Egborge, A.B.M (1994): Water pollution in Nigeria, Vol 1; Biodiversity and Chemistry of lake Asejire. *Nigeria freshwater Biology*: 4.177-191
- McCulloch, D.L. (1990): Metabolic Response of the Grass Shrimp *Palaemonetes kadiakensis* Rathburn to Acute Exposure to Sublethal Changes in pH. *Aquatic Toxicology* 17 (1990): 263-274.
- Olowosegun, O.M, T. Olowosegun and H. Mohammed, (2005): A review on the effect of water pollution on fish and the 'fishing industry of Nigeria. In *2005 FISON Conference Proceedings 14-18 Nov 2005* Port Harcourt, Nigeria pp: 423-428.
- Onuoha, G.U.C. (2009): *fundamental Principles of Fisheries Science*. New edition digital press, Umuahia, Abia state Nigeria. Pp 15-51.
- Stone, N.M and Thomforde, H.K (2004). Understanding Your Fish Pond Water Analysis Report. Cooperative Extension Program, University of Arkansas at Pine
- William, A.S. (2004): *Freshwater prawn culture: The Farming of Macrobrachium rosenbergii*. Blackwell Science, Oxford, England, 512.

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The Use of Activated Carbon in the Management Of Aquaculture Effluents: A Review

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Abstract

Environmental pollution, solid wastes and wastewater from fish pond effluents poses detrimental effects to the environment. These effluents are materials introduced into the rearing systems as feeds or drugs. They include uneaten fish feed, excreta (conventional pollutants), chemicals and therapeutants. Most recently, other emerging pollutants have been identified and they are pesticides, heavy metals, antibiotics and steroids. Over the years several conventional approaches have been adopted for the removal of these wastes in aquaculture ponds and hatcheries with varying degrees of success but they face critical challenges such as membrane fouling, high operation cost and the generation of toxic by-products. The biological method of using activated charcoal has been proved to be both reliable and cheaper, and thus is recommended for use.

Keyword: Activated charcoal, Aquaculture, Disease, Effluents, Management

Introduction

The increased use of resources such as land, water, feed and energy over the years has raised several environmental issues. Pollution from sewage and human wastes introduce pathogens into the water sources resulting in pathogenicity, infections and death of aquatic inhabitants (Kestemont, 1995; Phanet *et al.*, 2009). Most of these human-induced activities are very deleterious to aquatic organisms (Cruickilton and Duchrow, 1990). Alleged pollution-related diseases include epidermal papilloma, fin/tail rot, gill disease, hyperplasia, liver damage, neoplasia and ulceration (Austin, 1999). Specific examples of fish disease that reflect the effects of pollution include surface lesions attributed to *Serratia plymuthica*, fin and tail rot caused by *Aeromonas hydrophila* and *Pseudomonas fluorescens*, gill disease resulting from the activity of *Flavobacterium* spp, Vibriosis caused by *Vibrio anguillarum*, and enteric red mouth (causal agent, *Yersinia ruckeri*) (Austin, 1998).

Pollution Caused by Freshwater Aquaculture Effluents

In modern day aquaculture systems, the success rate depends upon the supply of nutrients. However, for some species, a large fraction of the food ration can remain uneaten as observed in the rearing of European eels and tilapias with spill around 1% - 10% and 10% - 30% of the ration, respectively (Bosmas and Verdegem, 2011). Aquacultural wastes include all materials used in the process which are not removed from the system during harvesting (Cripps and Bergheim, 2000). These wastes are mainly associated to uneaten feed or excreta (conventional pollutants), chemicals and therapeutants added to the ponds, and can be discharged either in the sediments or in the farm effluents. It is important to note that the characteristics of these aquaculture effluents are highly variable and is dependent on the type of fish species raised, the type of production facility and the feed quality and management; however, some general features can be drawn from (Table 1). Generally, the quality of aquaculture effluents can be compared to raw surface water than to domestic or secondary effluents, with low contents of total suspended solids (TSS), organic matter and total ammonium nitrogen as in the Table below. This situation can be attributed to runoff from catchment areas during rainfall. Hence, they find their way into rearing facilities.

Table 1. Comparison between different types of effluents and raw surface water

Parameters	Domestic effluents	Secondary effluents	Aquaculture effluents	Raw surface water
TSS(mg/l)	400-500	30	5-50	50-400
TNK(mg/l)	300-400	20	3-20	7
N-NH ₄ (mg/l)	40-75	5	0.4-0.5	0.05-0.50
BOD(mg/l)	300	20	0.2-0.5	2-4

Keys:

TSS: Total Suspended Solids

TKN: Total Kjeldahl Nitrogen

N-NH₄: Nitrogen-Ammonium
 BOD: Biochemical/Biological Oxygen Demand
 Source: Cripps and Bergheim(2000)

Pesticides, Heavy Metals and Emerging Pollutants

Intensive aquaculture often relies on chemical additives for health management, reproduction or growth promotion, among other purposes. Pesticides such as rotenone, simazine, 2, 4-D, diquat and diuron (Tacon, 2003; Pillay, 2004) are used essentially for weed control. Organophosphate compounds (malathion and dichlorvos), carbamates and pyrethroids are also used as parasiticides in aquaculture. Heavy metals can also be found in pond effluents because they are common constituents of proteins, vitamin and mineral premixes (e.g., Cu and Zn) (Davidson *et al.*, 2009). They also function as oxidizing agents for controlling phytoplankton and pathogenic organisms in fish ponds (e.g., potassium permanganate (KMnO₄) or as algicides, e.g., copper tetra-Oxo sulphate six acid (CuSO₄) (Boyd and Massaut, 1999). Presently, one of the main environmental concerns about aquaculture is the release of bactericides (glutaraldehyde, formalin), therapeutants (such as malachite green and dipterex) and antibiotics (mainly tetracyclines, quinolones and β -lactams) to the aquatic media (Boyd, 1991). Antibiotics are mostly found in the water of intensive farms rather than in extensive ones (Dietze *et al.*, 2005), most likely because in an intensive hatchery, fishes are subjected to more stressors that decrease the ability of their immune system to deal with infections (Cabello, 2006). Steroids are present in the blood plasma of fishes and can be excreted via urine or bile, mainly during periods of reproduction. The contents detected (of about 1 ng/L) of these emerging pollutants in aquaculture effluents are similar to those found in domestic secondary effluents and high enough to lead to adverse reproductive effects on aquatic species e.g. trouts (Kolodziej, 2004).

Effluents Management Using Activated Carbon Technology

Activated Carbon

Activated carbon otherwise known as activated charcoal uses adsorbent mechanism with controllable pore structure, high thermo-stability and low acid/base reactivity (Monsalvo *et al.*, 2011). This technology have proven versatile because of its low initial cost, simplicity of design, insensitivity to toxic substances, high adsorption capacity and regenerability for the removal of micro-pollutants from fish pond effluents (Mook *et al.*, 2012). Due to its high degree of micro porosity, a gram of activated carbon has a surface area in excess of 2972.9m² (32,000 sq. ft.) (Dillon *et al.*, 1989), as determined by gas adsorption. Activated carbon can be derived from charcoal and is sometimes utilized as bio-char. Those derived from coal and cokes are referred to as activated coal and coke respectively. Activated carbon when derived from coal can be used as a substrate for the application of various chemicals to improve the adsorptive capacity for some inorganic and problematic organic compounds such as hydrogen sulphide (H₂S), ammonia (NH₃), formaldehyde (HCHO), mercury (Hg) and radioactive iodine-131 in a process known as chemisorption (Idris *et al.*, 2018).

Production of activated carbon

Activated carbon is carbon produced from carbonaceous source materials such as nutshells, coconut husk, peat, wood, coir, lignite, coal, and petroleum pitch. It can be produced by one of the following processes:

1. **Physical activation:** The source material is developed into activated carbons using hot gases. Air is then introduced to burn out the gasses, creating a graded, screened and de-dusted form of activated carbon. This is generally done by using one or a combination of the following processes: carbonization or activation/oxidation
2. **Chemical activation:** Prior to carbonization, the raw material is impregnated with certain chemicals. The chemical is typically an acid, strong base, or a salt (phosphoric acid, potassium hydroxide, sodium hydroxide, calcium chloride, and zinc chloride 25%). Then, the raw material is carbonized at lower temperatures (450–900 °C). It is believed that the carbonization / activation step proceeds simultaneously with the chemical activation. Chemical activation is preferred over physical activation owing to the lower temperatures and shorter time needed for activating material.

Classifications of Activated Carbon

Activated carbons are complex products which are difficult to classify on the basis of their behaviour, surface characteristics and other fundamental criteria. However, some broad classification is made for general purposes based on their size, preparation methods, and industrial applications. They are; Powdered activated carbon (R 1, PAC), granular activated carbon (GAC), extruded activated carbon (EAC) and bead activated carbon (BAC).

Conclusion

Aquaculture effluents contain low concentrations of conventional pollutants (TSS, organic matter and nutrients), pesticides, heavy metals and emerging pollutants. Biological treatments are environmentally-friendly alternatives and cheaper for removing these pollutants. Hence, activated carbon-based biological filters are more appropriate for minimizing water exchange ratios without compromising the quality of fish production by the accumulation of growth inhibitors.

References

- Austin, B. (1998). The effects of pollution on fish health. *Journal of applied microbiology*, 85(S1), 234S-242S.
- Bosmas, R. H. and Verdegem, M. C. J. (2011). Sustainable Aquaculture in Ponds: Principles, Practices and Limits. *Livestock Science*, 139(1-2): 58-68.
- Boyd, C.E. and Massaut, L., (1999). Risks Associated with the Use of Chemicals in Pond Aquaculture. *Aquacultural Engineering*, 20(2): 113-132.
- Cabello, F.C. (2006). Heavy Use of Prophylactic Antibiotics in Aquaculture: A Growing Problem for Human and Animal Health and for the Environment. *Environmental Microbiology*, 8(7): 1137-1144.
- Cripps, S.J. and Bergheim, A. (2000). Solids Management and Removal for Intensive Land-Based Aquaculture Production Systems. *Aquacultural Engineering*, 22(1-2): 33-56.
- Cruickilton, R.L. and Duchrow, R.M. (1990). Impact of a massive crude oil spill on the invertebrate fauna of a Missouri Ozark stream. *Environmental Pollution*, 63(1) 13-31.
- Davidson, J., Good, C. Welsh, C., Brazil, B. and Summerfelt, S., (2009). Heavy Metal and Waste Metabolite Accumulation and Their Potential Effect on Rainbow Trout Performance in a Replicated Water Reuse System Operated at Low or High System Flushing Rates. *Aquacultural engineering*, 41(2): 136-145.
- Dietze, J., Scribner, E., Meyer, M.T. and Kolpin, D. (2005). Occurrence of Antibiotics in Water from 13 Fish Hatcheries, 2001-2003. *International Journal of Environmental Analytical Chemistry*, 85(15): 1141- 1152.
- Dillon, E.C., Wilton, J. H., Barlow, J. C. and Watson, W. A. (1989). Large surface area activated charcoal and the inhibition of aspirin absorption. *Journal of Emergency Medicine*, 18 (5): 547-552.
- Idris, M. R., Arifuzzaman, M., Basak, A., Saha, T., and Yasmin, J. (2018). Cost Effective Wastewater Treatment by Natural Adsorbent. *Journal of Chemistry and Chemical Sciences*, Vol.8(4), 777-785.
- Kestemont, P. (1995). Different Systems of Carp Production and Their Impacts on the Environment. *Aquaculture*, 129:1(347-372).
- Kolodziej, E.P., Harter, T. and Sedlak, D.L. (2004). Dairy Wastewater, Aquaculture and Spawning Fish as Sources of Steroid Hormones in the Aquatic Environment. *Environmental Science and Technology*, 38(23): 6377-6384.
- Mook, W. T., Chakrabarti, M. H., Aroua, M. K., Khan, G. M. A., Ali, B. S., Islam, M. S. and Hassan, M. A. (2012). Removal of total ammonia nitrogen (TAN), nitrate and total organic carbon (TOC) from aquaculture wastewater using electrochemical technology: a review. *Desalination*, 285:1-13.
- Monsalvo, V.M., Mohedano, A.F. and Rodriguez, J.J. (2011). Activated carbons from sewage sludge: application to aqueous-phase adsorption of 4-chlorophenol. *Desalination* 277: 377-382.
- Phan, L.T., Bui, T.M., Thuy, N.T.T., Gooley, G.F., Ingram, B.A., Hao, N.V.N., Phuong, N.T. and De Silva, S.S. (2009). Current status of farming practices of striped catfish, *Pangasianodon hypophthalmus* in the Mekong Delta, Vietnam. *Aquaculture* 296:227-236.
- Pillay, T.R.V. (2004). *Aquaculture and the Environment*, 2nd Edition, Blackwell, Oxford.
- Tacon, A. G., and Forster, I. P., (2003). Aquafeeds and the Environment: Policy Implications. *Aquaculture*; 226(1-40): 181-189.

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Prospects and Risks of Cage Culture in Nigeria

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Abstract

The awareness of culturing fish in cages as an alternative way of raising fish on a large commercial scale is gaining momentum and the vast bodies of water especially in coastal states of Nigeria can increase fish production and enhance job creation greatly. The technology of cage culture is simple, has low capital costs, and the operation is easy for all ages and genders. However, like any other investment, there are risks associated. This paper attempt to look at the risks, prospects and the challenges involved in fish cage culture as a viable alternative for fish culture in Nigeria.

Key words: Aquaculture, Cage, Coastal environment, Culture systems.

Introduction

Cage culture has great development potential. Given suitable sites, among fish culture methods, cage culture can be the most attractive of the raceway, tanks and cage culture systems. It requires less technology, has low capital costs in small-scale production, and requires virtually no land investment (FAO 2006). Today cage culture is receiving more attention from both commercial producers and researchers. Factors such as increasing consumption of fish, declining stocks of wild fishes and poor farm economy have increased interest in fish production in cages. Cage aquaculture involves the growing of fishes in existing water resources while being enclosed in a net cage which allows free flow of water. It is an aquaculture production system made of a floating frame, net materials and mooring system (with rope, buoy, anchor etc.) with a round or square shape floating net to hold and culture a large number of fish and can be installed in reservoir, river, lake or sea (Otubusin (2001).

There are 4 types of fish-rearing cages namely: i) Fixed cages, ii) Floating cages, iii) Submerged cages and iv) Submersible cages. Economically speaking, cage culture is a low impact farming practice with high returns and the least carbon emission activity. Farming of fish in an existing water body removes one of the biggest constraints of fish farming on land, i.e. the need for a constant flow of clean, oxygenated water. Cage farms are positioned in such a way to utilize natural currents, which provide the fish with oxygen and other appropriate natural conditions.

Given the high production attainable in the cage culture system, it can play a significant role in increasing the overall fish production. Suitable but underutilized water bodies can be better utilized by adopting cage culture. Since the investment is low and requires very little/no land area, this farming method is ideal for small scale fisher folks as an alternative income source. This can be taken up as a household/women activity since the labour involved is minimal and can be managed by a small family. Like every other investment, cage culture comes with some challenges. The objective of this paper therefore is to raise awareness on the basic benefits of setting up fish cage farming, point out the possible risks associated with cage culture and management practices to be put in place.

Methodology

An exploratory research approach was employed in this study through engaging existing literature, journals of various types in fisheries technology, across the globe. Content analysis of library materials, journal publications, internet materials and textbooks relevant to the subject matter were utilized for the study. The study relied on the secondary sources of data collection as it simply aims to point out the various opportunities available in fish cage culture. Secondary data are usually historical and already collected data that does not necessitate access to respondents or subjects (Ember & Levinson, 1991).

The Aquaculture sector in Nigeria

The world's population is expected to rise to more than 9 billion by 2050 eliciting a 70% increase in global demand for food, feed and fibre, Nigeria may contribute 250 million of that number. Fish is an important part of the human diet and provides about 20% of animal protein intake, globally. On one hand, it serves as a healthy food for the

affluent world owing to its oil- rich in polyunsaturated fatty acids (PUFAs) and on the other hand, fish is a healthy food owing to its proteins, oils, vitamins and minerals and other benefits associated with the consumption of small indigenous fishes by the people in the other extreme of the nutrition scale. According to Surjya *et al.* (2014) fisheries and aquaculture contribute significantly to food security and livelihoods. Fish provides essential nutrition and at least 50% of animal protein and minerals. Aquaculture is the world's fastest- growing food production system, growing at the rate of 7% annually and fish products are among the most widely traded food, with more than 37% (by volume) of world production traded internationally.

Aquaculture, the rational rearing of aquatic organisms, addresses poverty and food insecurity through a variety of routes and at various scales (Beveridge *et al.*, 2010). The wild fish stocks have remained static over the past three decades (FAO, 2020), thereby accentuating the significance of aquaculture in meeting up with the world food demand, by providing half of all fish for human consumption. Aquaculture is the world's fastest- growing food production system, growing at the rate of 7% annually and fish products are among the most widely traded food, with more than 37% (by volume) of world production traded internationally. With a yield of farmed fish of 316,727 metric tons (FDF, 2018), Nigeria ranks second in Africa and is listed among the top twenty-five aquaculture producers in the world (FAO 2020). Aquaculture production in the country has increased five-fold within a decade. With the vast bodies of water in Nigeria – Rivers and lakes, lagoons and the nearshore waters, the opportunities for fish cage culture in Nigeria is immense.

Advantages

Fish cage culture has advantages which include:

1. Many types of water resources can be used, including lakes, reservoirs, ponds, strip pits, streams and rivers, lagoons that could otherwise not be harvested.
2. The fish cage system requires low initial capital than starting a pond culture operation.
3. Harvesting is simplified. Fish harvesting is generally simplified because the entire cage can be taken from the water and the fish removed or simply scooped out with a net.
4. High-value carnivorous fish species such as groupers, snappers can be raised in small cages in inshore environments.
5. Observation and sampling of fish is simplified,
6. allows the use of the pond for sport fishing or the culture of other species,
7. less manpower requirement,
8. generation of job opportunities for unemployed youth and women,
9. additional income to fishers during closed seasons.

According to Surjya Narayan Datta *et al.* (2014), the performance of fish raised in a pond with a cage was better than those raised without a cage.

Risk (Perceived Issues and Challenges to Cage Culture Development)

1. There is a risk that the fast growth of intensive operations can marginalize small-scale producers and high production at different levels of intensity can lead to environmental degradation if not properly planned and managed. Considering that most of the cage aquaculture takes place in the fragile yet already much pressured coastal environments, there is increasing agreement that particular emphasis has to be given to the environmental sustainability of the sub-sector.
2. increased nutrient loss from uneaten feed, faecal wastes and excreta from cage-reared fish and possible impacts (negative and/or positive) upon water quality and surrounding aquatic environment and ecosystem health (Mente *et al.*, 2006; León, 2006);
3. Increased risk of disease occurrence within cage reared fish and the potential risk of transfer of diseases to (and from) natural fish populations (Merican, 2006).
4. Application of chemicals for Chemotherapeutic in open cages will have serious environmental consequences apart from non-target species safety.(Vijayan *et al.*, ,2015).
5. Increased dependency of cage-reared carnivorous fish species upon fishery resources as feed inputs, including fishmeal, fish oil, and low-value “trash fish” species. Note this dependency is not unique to cage farming systems, and also applies to pond and tank reared carnivorous fish and crustacean species;
6. Increased dependence of some cage-farming systems upon the capture of wild -caught seed, and in particular for those marine fish species where hatchery development is new or production is not currently sufficient to meet demand (FAO, 2006; Merican, 2006)

7. Increased risk of fish escapes from cages and consequent potential impacts (negative and/or positive) on wild fish populations, including potential genetic, ecological and social impacts (FAO, 2006);
8. Increased potential impacts of cage farming activities (negative and/or positive) upon other animal species, including predatory birds and mammals attracted to the fish within the cages (Beveridge, 2004; Nash *et al.*, 2000);
9. Increased community concerns (in some countries) regarding the use of shared public inland and coastal water bodies for rearing fish within cage-based farming systems (due to the possible displacement of fishers and others, and/or perceived visual pollution), and the consequent need for increased consultation with all stakeholders (FAO, 2006);
10. Increased need for establishment and implementation of adequate government controls concerning the development of the sector, including planning and environmental monitoring, and implementation of good/better on-farm management practices (FAO, 2006).
11. Increased public concerns (in some countries and developed country markets) regarding the long term environmental and ecological sustainability of the intensive farming systems, and in particular concerning the long-term ecological sustainability of rearing carnivorous fish species within cage-based farming systems based upon the use of fishery resources as feed inputs. It is important to repeat here that aquaculture (including the use of cage farming systems) has also numerous important social, economic and environmental benefits, including increased food security and poverty alleviation impacts, increased employment opportunities within rural communities, increased seafood supply and availability, improved human nutrition.

Conclusion

Clearly, with the world's population growing at a rate of more than 80 million people a year, and expected to reach 9 billion by 2050, there is no doubt that our oceans and precious freshwater resources will have to become more efficient and productive in terms of increased global aquaculture food production.

The opportunities for cage culture to provide fish for the world's growing population are enormous, particularly so in marine waters with more than 97 per cent of all our planet's water being contained in the ocean. Cage aquaculture will play an important role in the overall process of providing enough (and acceptable) fish for all, particularly because of the opportunities for the integration of species and production systems in nearshore areas as well as the possibilities for expansion with siting of cages far from the coasts. For Nigeria, a time like this when some parts seem to be a no go area because of insecurity, our lagoons becomes the best opportunities for utilization to achieve much of our fish production. In a water space of less than an acre, more than a hundred tons of fish can be produced. Lagos state is currently taking a lead in this aspect.

References

- Beveridge, Malcolm, Michael Phillips, Dugan, Patrick and Randy; Brummet 2010 Barriers to aquaculture development as a pathway to poverty alleviation and food security: In book: Advancing the Aquaculture Agenda: pp. 345-359
- FDF 2018. Fisheries Statistics of Nigeria. 2008- 2015. 5th Edition. Federal Department of Fisheries, Federal Ministry of Agric. And Rural Development, Abuja, Nigeria pp. 53.
- FAO. 2020. *The State of World Fisheries and Aquaculture 2020. Sustainability in action*. Rome. Retrieved from <https://doi.org/10.4060/ca9229en>
- Ferguson, A., Fleming, I.A., Hindar, K., Skaala, Ø., McGinnity, P., Cross, T. & Prodöhl, P. 2007. Farm escapes. In E. Verspoor, L. Stradmeyer & J. Nielsen (eds), *Atlantic Salmon: Genetics, conservation and management*, pp. 367–409. Oxford, Blackwell Publishing Ltd.
- K.K. Vijayan, K.V. Rajendran, N.K. Sanil & S.V. Alavand (2015): 5th International symposium on Cage Aquaculture, Asia .Symposium CAR-Central Institute of Brackishwater Aquaculture pp 103
- León, J.N. 2006. Synopsis of salmon farming impacts and environmental management in Chile. Consultancy Technical Report. Valdivia, Chile, WWF Chile. 46 pp.
- Mente, E., Pierce, G.J., Santos, M.B. & Neofitou, C. 2006. Effect of feed and feeding in culture of salmonids on the marine aquatic environment: a synthesis for European aquaculture. *Aquaculture International*, 14: 499–522.
- Merican, Z. 2006. Marine finfish cage culture: some of the strengths, weaknesses, opportunities and threats facing this expanding yet fragmented industry in China and Southeast Asia. *AQUA Culture AsiaPacific Magazine*, 2(2): 22–24

- Nirmal Singh, Surjya Narayan Datta and Tarvinder Singh Handa. 2016. Research dynamics in Indian fisheries and aquaculture: a scientometric analysis. Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana 141 004, India,
- Otubusin. S.O. (2001): Economics of Small Scale Tilapia Production in Floating Net-Cages. An International journal of Agricultural Sciences, Environment and Technology. Series A: Agriculture and Environment. Asset series A (2001) volume I Number I. ISSN 1595-9694 (S) UNAAB 2001.
- Tan, Z., Komar, C. & W.J. Enright. 2006. Health management practices for cage aquaculture in Asia: A key component for sustainability. In Book of Abstracts, 2nd International Symposium on Cage Aquaculture in Asia (CAA2), 3-8 July 2006, Hangzhou, China, pp. 5–7. (Proceedings - in press).
- Surjya Narayan Datta, Asha Dhawan, Sachin Kumar, Pranaya Parida and Kulwinder Kaur (2014). College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University Ludhiana 141004, Punjab, India

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Anaesthesia and Survival Rate of Different Life Stages of African Catfish (*Clarias gariepinus*) Exposed to Clove (*Eugenia Caryophyllata*) Powder

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Abstract

This study investigated the effects of clove (*Eugenia caryophyllata*) powder on anaesthesia, recovery and survival in different life stages of *Clarias gariepinus*. Four hundred and fifty (450) fish comprising of 150 each of mean weight: fingerlings ($6.54 \pm 3.25\text{g}$), juveniles ($15.06 \pm 2.50\text{g}$) and adults ($32.10 \pm 4.30\text{g}$) were used for the study. The fish were exposed to 100, 120, 140, 160 and 180mg/l of the anaesthetic prepared from a stock solution of 200mg/l of the clove powder. Ten (10) fish each were used per tank in triplicate for each life stage. The time to attain various stages of anaesthesia and recovery was noted and recorded. Mortality for each life stage was also recorded. Some water quality parameters were monitored and recorded. The powder was observed to cause anaesthesia which was dependent on the concentration and sizes of the exposed fish. The time to attain deep anaesthesia (stage A3) decreased with increasing concentration in all the life stages but longer in adults than juveniles and fingerlings. The shorter the time to achieve stage A3 the longer the time to be fully recovered. The survival rates of 86.67 and 96.67% were recorded for fingerlings and juveniles respectively in higher concentrations of the anaesthetic while in the adults was 100%. The study revealed that clove bud can effectively be utilized as anaesthetics agent in *C. gariepinus* at optimal dose of 160mg/l.

Keywords: Anaesthesia, Recovery, Survival, Life stages and Clove buds

Introduction

Anaesthetics are used in aquaculture and fisheries to facilitate various routine procedures that can often cause physical injury and induce physiological stress (Ross and Ross 2008). They are also used to immobilize fish so they can be handled more easily during harvesting, sampling and spawning procedures. Sedatives and anaesthetics are very useful in aquaculture as they reduce fish activity, limit oxygen consumption and facilitate routine handling and veterinary procedures (Husen and Sharma, 2014). Anaesthesia is a biological reversible state induced by an external agent, which results in the partial or complete loss of sensation or loss of voluntary neuromotor control, through chemical or non-chemical means (Summerfeld and Smith, 1990). Anaesthesia is frequently applied in aquaculture being a valuable tool that helps to minimize fish stress and to prevent physical injuries to fish while handling them during routine practices. Anaesthesia is required for measuring or weighing fish, sorting and tagging, administering vaccines, live transport, sampling for blood or gonadal biopsies and collecting of gametes, surgical procedures, to cite some of the main applications (Maricchiolo and Genovese, 2011).

Knowledge about the ideal and optimum concentration of anaesthetics for various fish species is necessary because inappropriate concentrations may lead to adverse effects such as stress; therefore, access to safe and effective fish sedatives is a critical need of fisheries researchers, managers, and culturists (Trushenski *et al.*, 2013).

The choice of anaesthetics is usually related to several factors such as availability, economic viability, practicality of use, efficacy, user safety and chemical substances approved by regulatory agencies in animals for human consumption (Cho and Heath 2000; Goncalves *et al* 2008). However, most desirable attributes of anaesthetics used for fin fish include short induction and recovery time, non-toxicity to fish and humans, no lasting physiological effects, rapid clearance from the body, high solubility in fresh and salt water and cost effectiveness (Marking and Meyer 1985). Recovery should be attained within few minutes to prevent stress and harmful effects on the fish (Woods *et al* 2008). According to Marking and Mayer (1985) the most desirable recovery is set to be retained within 5 minutes. After anaesthetics procedure the fish is recommended to be under closer observation for 24 – 72 hours as

death can occur (Ross and Ross 2008). Mortality of fish exposed to anaesthetic depend on a number of factors which include duration of exposed, concentration of the substance, species and size of the exposed fish.

Variety of anaesthetics (natural and synthetics) are widely used in the laboratories, aquaculture activities and veterinary procedures to mitigate stress. Most commonly used are metomidate, benzocaine, etomidate, MS-222 (Tricaine methane sulphonate), 2- phenoxyethanol, quinaldin and eugenol (Ross and Ross 2008; Yanar and Kumlu 2000; Velisek *et al* 2006). Synthetics anaesthetics metomidate, benzocaine, etomidate, 2 – phenoxyethanol and MS-222 used in aquacultural operations have some challenges such as poor solubility, long induction and recovery time, highly toxic and low dose, health risk to humans and high cost of the chemicals (Iversen *et al* 2003; Palic *et al* 2006). In recent times organic farming provided alternatives for those chemicals that are currently being used in aquaculture and anaesthetics are one of such important input, hence different natural anaesthetics were investigated to compare their effectiveness with chemical products (Taylor and Roberts, 1999). Plant extracts from Deris (rotenone), pyrus, tobacco, mustard seed, clove, ocimum, and menthe have been reported to induce anaesthesia with little or no side effects on fishes (Agokei and Adebisi, 2010; Adebayo *et al* 2010; Ribeiro *et al* 2016; Adewale *et al* 2017; Wilfred- Ekipirikpo 2021). Clove products (leaves, stems, flower and buds) contains mainly eugenol (4- ally-methoxyphenol) and (4- propenyl- 2 – methoxyphenol) have shown to be potential and effective anaesthetic for food fishes (Sudagara *et al*. 2009; Okey *et al* 2013; Javahery *et al* 2012; Akinrotimi *et al*. 2015).

African catfishes constitutes the largest group of cultured species after carp, salmonids, tilapias and they grow well under various culture systems of the world. Their culture is becoming more popular among retirees civil and public servants in Cross River, where they are transported from hatcheries sites to grow out ponds and research laboratories (Okey, 2019). Previous studies on the use of clove flower buds powder as anaesthetic on *Clarias gariepinus* and *Heterobranchus bidorsalis* juveniles and fingerlings on different concentrations have been reported (Okey *et al.*, 2018; Okey, 2019). Information on the anaesthesia and survival rate of the different life stages (fingerling, juveniles and adults) of *C. gariepinus* exposed to the same concentration of clove powder anaesthesia is still scanty. Therefore this study is aimed to determine the optimal dosage for induction, recovery and survival rate of the various life stages of *C. gariepinus* on clove powder.

Materials and Methods

Study location and experimental fish

The study was conducted at the Department of Fisheries and Aquatic Science, Faculty of Agriculture, Cross River University of Technology, Obubra campus. Four hundred and fifty (450) comprising of 150 each of mean weight and length: fingerlings ($6.54 \pm 3.25\text{g}$), juveniles ($15.06 \pm 2.50\text{g}$) and adults ($32.10 \pm 4.30\text{g}$). Were procured from Ezema fish farm in Ikom, Cross River state. They were acclimated at Fisheries wet labouratory for 14 day during which they were fed with coppen feed at 5% body weight and discontinuous 24 hours prior to the commencement of the bioassay.

Collection and preparation of Clove powder: Dry flower buds of clove was purchased from a herbal shop in watt market Calabar Cross River, Nigeria. The product was authenticated at the Department of Forestry and Wildlife Faculty of Agriculture and Forestry CRUTECH, Obubra campus. The buds were sundried for 30 minutes and then pulverized with a manual blended and sieved with 100 micron net to obtain a fine powder. The powder was stored in an airtight container prior to the commencement of the experiment.

Experimental procedure: Two (2g) gram of the powder was weighed and dissolved in 10 litres of water to prepare a stock solution of 200mg/l. Exposure concentrations of 100, 120, 140, 160 and 180mg/l was prepared from serial dilution of the stock solution in triplicates to 40L plastic aquaria. The mixtures were stirred thoroughly to ensure homogeneity of the test solution. Ten (10) fish of the same life stage were randomly selected into the test aquaria and monitored for the onset of the various stages induction and recovery and recorded for 30 minutes according Kings *et al* (2015). Three (3) behavioral stages each were identified for induction and recovery according to (Coyle *et al* 2004).

Table 1: Stages of Anaesthesia and Recovery of the various life stages of *C. gariepinus* to clove powder anaesthetic

Stages Anaesthesia A)	Condition	Behaviour/ Response
A1	Light sedation	Partial loss of muscle tone and erratic swimming
A2	Light anaesthesia	Complete loss of balance, slow ventilation or opercula rate
A3	Deep anaesthesia	Total loss of muscle tone and reaction to handling or external stimulus.
Recovery (R)		
R1	Initial recovery	Commencement of opercula movement.
R2	Partial recovery	Return of erratic swimming, irregular balance and partial return to equilibrium
R3	Full recovery	Normalization of equilibrium, swimming and responses to tactile stimulation.

Source: Coyle *et al* (2004), Modified by Gressler *et al.*, 2017

Survival rate: The number of death fish during the period of anaesthesia, recovery and 24 hours after the completion of induction and recovery were noted and recorded according to Ross and Ross (2008). This was used to compute the survival rate (%) according to Adikwu, (2003) as

$$\text{Survival rate (\%)} = \frac{\text{Number of fish at the final}}{\text{Initial number of fish}} \times 100$$

Water Quality parameters: The temperature of the media was taken using a mercury in glass thermometer, pH values were determined using pH meter, Dissolved Oxygen was determine using Dissolved oxygen meter inserted into the sample glass tanks after standardization in three different buffers. Conductivity was measured with conductivity meter (PACM 35 model) and total hardness by ethylene diamine tetra acetic acid titration method.

Statistical analysis: Statistical Data analysis: the data collated was subjected to two way analysis of variance using a statistical software SPSS version 25 to compute for the significant differences among the variables of clove powder, stages of anaesthesia, recovery and life stages of the experimental fish. The differences among the means were compared using Turkey's multiple comparison test at 5% significance level (Bhujel 2008).

Results

Water quality

The result of the water quality parameters (Table 2) indicates that the mean values did not differ significantly ($p > 0.05$) from those of the control in the various life stages of the exposed fish. However, dissolved oxygen, temperature, pH and hardness all decreased slightly with increasing concentration. Conductivity increased slightly from 136.07 ± 2.04 in the control to 137.05 ± 2.71 at 180mg/l tank whereas the mean value of pH (6.78 ± 0.28 to 6.57 ± 0.22) was relatively closed.

Table 2: Water quality parameters of the test solutions for *C. gariepinus* exposed to Clove powder anaesthetic for 30 minutes (mead $\pm$ SD)

Conc. (mg/l)	Parameter					
	DO (mg/l)	Tempt. (°C)	pH	Cond. (μ S/cm)	Alk. (mg/l)	Hardness (mg/lCaCO ₃)
0	4.74 $\pm$ 0.27 ^a	28.13 $\pm$ 1.07 ^a	6.78 $\pm$ 0.28 ^a	136.07 $\pm$ 2.04 ^a	37.41 $\pm$ 0.45 ^a	39.32 $\pm$ 0.81 ^a
100	4.37 $\pm$ 0.35 ^a	26.87 $\pm$ 1.25 ^a	6.73 $\pm$ 0.27 ^a	136.51 $\pm$ 1.31 ^a	38.18 $\pm$ 1.96 ^a	37.61 $\pm$ 0.58 ^a
120	4.48 $\pm$ 0.12 ^a	27.37 $\pm$ 0.78 ^a	6.69 $\pm$ 0.41 ^a	135.96 $\pm$ 1.32 ^a	40.76 $\pm$ 2.69 ^a	38.33 $\pm$ 0.54 ^a
140	4.38 $\pm$ 0.36 ^a	26.67 $\pm$ 1.02 ^a	6.69 $\pm$ 0.16 ^a	136.79 $\pm$ 2.14 ^a	36.75 $\pm$ 0.85 ^a	38.72 $\pm$ 0.83 ^a
160	4.38 $\pm$ 0.38 ^a	27.74 $\pm$ 0.91 ^a	6.67 $\pm$ 0.19 ^a	137.23 $\pm$ 2.50 ^a	38.67 $\pm$ 1.05 ^a	38.26 $\pm$ 0.33 ^a
180	4.12 $\pm$ 0.12 ^a	26.88 $\pm$ 0.19 ^a	6.57 $\pm$ 0.22 ^a	137.05 $\pm$ 2.71 ^a	38.51 $\pm$ 0.47 ^a	38.80 $\pm$ 0.85 ^a

Mean with the same superscript in the same column are not different ($P > 0.05$, DO = dissolved oxygen, Tempt. = Temperature, Cond. =Conductivity, Alk. =alkalinity).

Anaesthesia and Recovery

The result of the mean time for the various stages of anaesthesia and recovery on the life stages of *C. gariepinus* exposed to clove powder anaesthetics is presented in tables 3 – 5. The result showed that clove powder resulted in different stages of anaesthesia and recovery times depending on the dosage and sizes of the exposed fish. The lower the dosage the longer the time in the various stages of anaesthesia (induction) and recovery. Fingerlings exposed to 180mg/l took only about 0.51 mins to be completely immobilized (deep anaesthesia) and 30.45mins to fully recover (table 3). In juveniles 180mg/l caused deep anaesthesia (A3) in 2.25mins and fully recovers at about 15.55mins (table 4) while adults 6.43 mins was required to attain complete immobilization and fully recovers in 8.52 mins (table 5). The low the time required for the onset of anaesthesia the higher the time to attain full recovery. In fingerlings the time to attain each stage of anaesthesia reduced significantly ($p < 0.05$) with increasing concentration whereas that of recovery increased significantly ($p < 0.05$) from 100 – 180mg/l. similar trend was obtained in juveniles and adult *C. gariepinus* exposed to clove anaesthetic.

Table 3: The mean time (mins) for anaesthesia and recovery of *C. gariepinus* fingerlings exposed to clove powder for 30 mins

Conc. (mg/l)	Stages Anaesthesia (A)			Stages of Recovery (R)		
	Sedation (AI)	Light Anaesthesia (A2)	Deep Anaesthesia (A3)	Initial Recovery (R1)	Partial Recovery (R2)	Full Recovery (R3)
100	4.33± 0.09 ^a	5.76± 0.27 ^a	7.06± 1.50a	1.65± 0.18d	2.03± 0.45e	4.25± 1.34d
120	2.56± 0.18b	3.15± 0.12b	4.83± 0.75b	2.86± 0.54d	4.07± 1.04d	5.87± 0.65d
140	1.07± 0.54c	1.86± 0.15c	3.05± 0.45b	5.02± 0.25c	10.01± 1.02c	14.50± 0.84c
160	0.20± 0.25c	0.30± 0.05d	1.15± 0.20c	11.55± 1.05b	17.83± 2.04b	27.52± 2.15b
180	0.00± 0.00	0.00± 0.00	0.51± 0.02d	16.55± 1.18a	23.58± 2.05a	30.45± 2.74a

Table 4: The mean time (mins) for anaesthesia and recovery of *C. gariepinus* juveniles exposed to clove powder for 30 mins

Conc. (mg/l)	Stages Anaesthesia (A)			Stages of Recovery (R)		
	Sedation (AI)	Light Anaesthesia (A2)	Deep Anaesthesia (A3)	Initial Recovery (R1)	Partial Recovery (R2)	Full Recovery (R3)
100	15.14± 1.25a	20.51± 2.06a	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00
120	7.33± 1.07b	9.06± 0.45b	11.48± 0.15a	1.85± 0.74c	2.46± 0.22d	4.40± 0.24d
140	5.62± 0.65c	7.44± 0.56c	9.03± 0.08b	2.64± 0.06c	4.05± 0.35c	7.23± 0.47c
160	2.02± 0.55d	3.58± 0.35d	5.48± 0.55c	4.13± 0.75b	7.08± 0.98b	13.58± 1.18b
180	1.08± 0.35d	1.95± 0.93e	2.25± 0.47d	6.24± 0.24a	9.11± 0.11a	15.55± 0.56a

Means with the same superscript under the same columns are not significant at 5%

Table 5: The mean time (mins) for anaesthesia and recovery of *C. gariepinus* adults exposed to clove powder for 30 mins

Conc. (mg/l)	Stages Anaesthesia (A)			Stages of Recovery (R)		
	Sedation (AI)	Light Anaesthesia (A2)	Deep Anaesthesia (A3)	Initial Recovery (R1)	Partial Recovery (R2)	Full Recovery (R3)
100	18.34± 0.24 ^a	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00
120	10.58± 0.05 ^b	19.08± 0.18 ^a	0.00± 0.00	0.00± 0.00	0.00± 0.00	0.00± 0.00
140	7.73± 1.02 ^c	10.22± 0.54 ^b	13.43± 0.72 ^a	1.34± 0.02 ^b	2.68± 0.10 ^b	3.04± 0.22 ^c
160	5.28± 0.55 ^d	7.58± 0.47 ^c	9.52± 0.36 ^b	2.56± 0.70 ^b	4.08± 0.18 ^a	6.35± 0.67 ^b
180	4.08± 0.56 ^d	5.57± 0.35 ^d	6.43± 1.18 ^c	4.42± 0.92 ^a	5.56± 0.22 ^a	8.52± 0.65 ^a

Means with the same superscript under the same columns are not significant at 5%

The time to achieved deep anaesthesia in fingerlings were lower with higher full recovery time when compared to that required by juveniles and adults (Figure 1). The survival rates of exposed fish is presented in Figure 3. The result revealed that survival of the life stages were dependent on the concentration and sizes of the fish. The survival rates of 100, 96.67 and 86.67% were recorded for adults, juveniles and fingerlings respectively exposed to the various concentration (100 – 180mg/l) under investigation. The mortality rate recorded for juveniles was not significantly different ($p > 0.05$) form those of the adults.

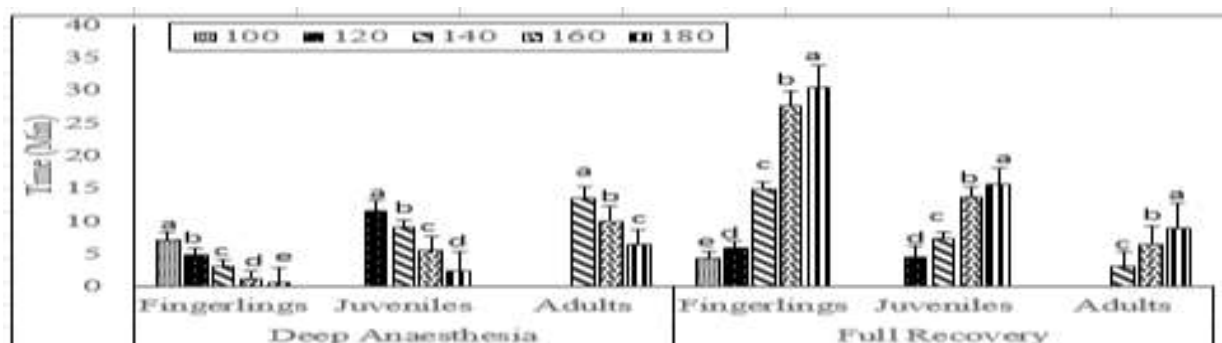


Figure 1: Deep anaesthesia and full recovery time in the life stages of *C. gariepinus* exposed to clove powder anaesthetic for 30 mins. Bar with different letter differ significantly at 5% (HSD)

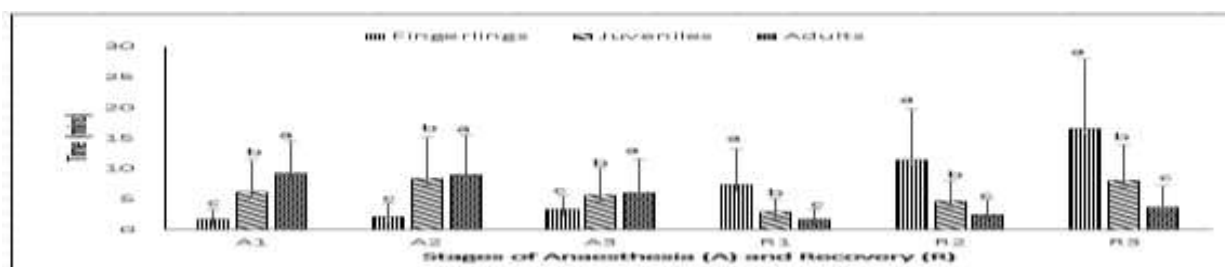


Figure 2: Comparison of the various stages of anaesthesia and recovery time (min) of the life stages of *C. gariepinus* exposed to clove powder anaesthetic for 30 mins. Bar with different letter differ significantly at 5% (HSD)

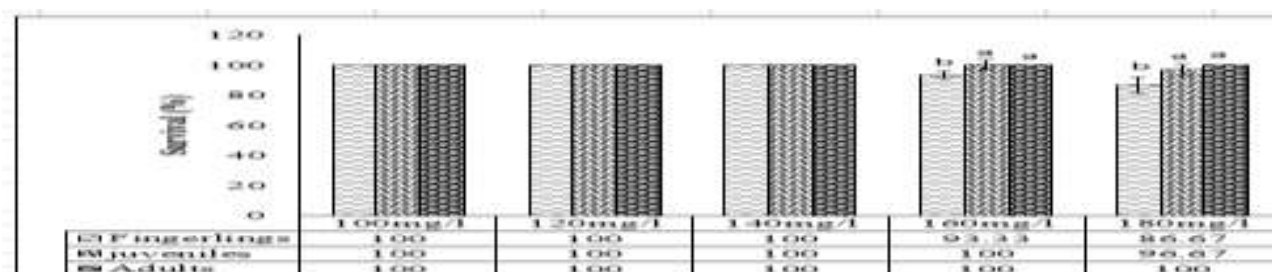


Figure 3: Survival rate (%) in the life stages of *C. gariepinus* exposed to clove powder anaesthetic for 30 minutes

Discussion

Water quality parameters

The water quality parameter of the test media did not differ ($p > 0.05$) from those of the control tanks. The slight changes in some of the parameter were still within the acceptable and tolerable range for culture of African catfishes. This therefore may not have acted synergistically with the anaesthetic (clove) to cause the behavioural changes and mortality recorded in this study. This findings agrees with Akinrotimi and Aiyelaja (2018), Okey *et al* (2018) on *C. gariepinus* juveniles exposed to clove seed and flower buds respectively.

Anaesthesia and Recovery

Anaesthetics are needed for easy handling, sorting, transporting and surgical procedures in aquaculture and fisheries (Ross and Ross 1999). Ideal anaesthetic ought to induce anaesthesia quickly in less than 6 minutes at low concentration, recovers faster in less than 10 mins, less toxic to the exposed fish, not hazardous to human and be inexpensive (Mylonas *et al* 2005). The observed behavioural changes under the various stages of anaesthesia and recovery in this study appears to be concentration dependent. Shorter immobilization time was achieved at higher concentrations of the clove powder as was reported in other plant based anaesthetics used by other workers (Okey *et al* 2013; 2018; Akinrotimi *et al* 2018; Teixeira *et al* 2017; Wilferd – Ekprikpo 2021). The progression through these various stages of anaesthesia and recovery was consistent with the descriptions by Keene *et al* (1998), King *et al*

(2005), and Zaikov *et al* (2008). According to Feng *et al* (2011), Summerfelt and Smith (1990), the degree of anaesthesia is influenced by the concentration of anaesthetic in the central nervous system (CNS) of the exposed organism. In this study fingerlings had lower induction and higher recovery times than juveniles and adults. This implies that the rate of absorption of clove powder (anaesthetic) is faster in fingerlings than juveniles and adults. This agrees with the findings of Wilfred – Ekpirikpo in *S. melanotheron* exposed to mustard seed and Okey (2014) in fingerlings and juveniles of *C. gariepinus* exposed to different ranges of concentrations of clove powder. In this study rapid deep anaesthesia of less than 4 mins for fingerlings and juveniles was induced with higher concentrations 140 – 180mg/l. Sudagara *et al* (2009) found that 350mg/l of clove powder solution was required to completely immobilize *Rutilus rutilus* in less than 4mins while Velisek *et al* (2005) reported a similar time with 80mg/l of clove oil on European catfish (*Silurus glanis* L) juveniles and described clove anaesthetic as effective and safe. Several workers have also reported induction time of 2 – 8 mins using clove oil of 30 – 100mg/l on *Oncorhynchus mykiss* (Keene *et al.*, 1998), *Anguilla reinholdtii* (Walsh and Pease 2002), *Esox lucius* (Zaikov *et al* 2008) and *Brycon cephalus* (Inoue *et al* 2005). These ranges were lower than the effective dosage of 140 – 180mg/l of clove powder solution recorded for *C. gariepinus* in this study. However a much higher range has been reported by some researchers using plant extracts to induce anaesthesia in 2 – 6 mins with *Pyrus communis* on *C. gariepinus* (Adebayo *et al* 2010), *Lippia alba* on silver catfish, *Rhamdia quelen* (Cunha *et al* 2010) and extracts from *Mentha piperita* on *Colossoma macropomum* (Facanha *et al* 2005). The differences in the effective dosages can be attributed to the specific properties of the species and pharmacokinetics of the anaesthetic agents (Mitjana *et al* 2014). Kucuk (2010) reported that the gill area, body weight, species and metabolic rate have effects on the rate of absorption and induction of anaesthetics. Lower concentration of anaesthetics should be encouraged to provide a greater margin of safety for that animal to avoid expenses and waste of anaesthetic solution (Teixeira *et al* 2017). Some authors have also suggested that the criteria for determining anaesthetic efficacy include: anaesthesia in less than 6 mins, fast recovery of not more than 15 mins except for surgical operations, easy to handle, cheap, highly soluble in water and without mortality (Ross and Rose 2008; Carneiro *et al* 2019). Based on these criteria clove powder can effectively be used at 140 – 160mg/l for the life stages since the fish were completely immobilized in less than 2 – 9 mins and no significant mortality recorded for fingerlings at the higher concentration. Recovery time increases as induction time reduces with increase in concentration of clove powder in all the life stages in this study.

After anaesthetic procedure the fish is recommended to be under closer observation for 24 – 72 hours as death can occur (Ross and Ross 2008). The zero mortality recorded for adults and 3% and 13% for juveniles and fingerling at higher concentrations is a proof the clove is an ideal anaesthetic for *C. gariepinus*. Similar trend in the survival rates was recorded for fingerlings and juveniles of *S. melanotheron* exposed to higher concentrations of mustard seed powder (Wilfred – Ekpirikpo 2021). Death can be attributed to the fact that, at higher concentrations the fish was unable to counter the effects of the increase and self- mechanism against cell destruction.

Conclusion

Dry clove bud powder is effective, highly soluble in water, relatively safe especially at low dosage, economically sustainable and ecologically friendly. This study proved that clove powder solution can effectively be utilized to induce anaesthesia in all the life stages of *C. gariepinus* and very short time depending on the dosage. Fingerling and juveniles should not be exposed to concentrations above 180mg/l to avoid significant mortality. Concentration of 140mg/l of clove powder is effective to completely immobilize all the life stages under investigation though at different intervals without mortality recorded. The use of clove powder should be encouraged in fisheries and aquaculture in preference of the synthetic anaesthetics which are expensive, scary, and difficult to handle for sustainability of the industry.

References

- Adebayo, T. O., Fasakin, E. A. and Popoola, O. M. (2010). Use of Aqueous Extracts of Avocado Pear, *Pyrus Communis*, Leaf as Anaesthetic in Gonadectomy of African Catfish, *Clarias gariepinus*. Journal of applied Aquaculture, 22(2):117-122.
- Adewale, A. Y., Adeshina, I. and Yusuf, O. Y (2027). Anaesthetic effect of *Ocimum gratissimum* extracts on *Oreochromis niloticus* juveniles. European Journal of Experimental Biology, 7(2):1-4.
- Adikwu, I. A. (2003). A Review of Aquaculture Nutrition in Aquaculture Development in Nigeria. In: Proceeding of National Workshop on Fish Feed Development and Feeding Practices in Aquaculture. Fisheries Society of Nigeria/NIFFR/FAO-NSPFS, New Bussa, 34-42.
- Agokei, O. E. and Adebisi, A. A. (2010) Tobacco as an anaesthetic for fish handling procedures. Journal of Medicinal Plants Research, 4(14), 1396 -1399.

- Akinrotimi, O. A., Gabriel, U. U. and Edun, O. M. (2015). The Efficacy of Clove Seed Extracts as an Anaesthetic Agent and Its Effect on Haematological Parameters of African Catfish (*Clarias gariepinus*). *Int J Aquac Fishery Sci* 1(2): 042- 047.
- Akinrotimi, O.A. and Aiyelaja, J.O. (2018). "Effectiveness of Nutmeg extracts as anaesthetics in transportation of *Tilapia guineensis*. In Ndimele, P.E. (eds). ." In 33rd Annual Conference of the Fisheries Society of Nigeria, October 29th –November 2nd, 2018, Ikorodu, Lagos State Nigeria. pp. 67-70.
- Bhujel, R. C. (2008). *Statistics for Aquaculture*. John Wiley & Sons.
- Carneiro, W. F., Melo, N., Da Silva, K.C.D., Ferreira, I.S., Paula, D.A.J., Ferrante, M., and Murgas, L.D.S (2019). Clove oil as anaesthetic for tambacu juveniles (σ^7 *Piaractus mesopotamicus* $\times$ ϕ *Colossoma macropomum*). *Adv. Anim. Vet. Sci.* 7(11): 969-976.
- Cho, G. K. and Heath, D. D. (2000). Comparison of tricaine methanesulphonate (MS222) and clove oil anaesthesia effects on the physiology of juvenile chinook salmon (*Oncorhynchus tshawytscha* Walbaum). *Aquaculture Research*, 31: 537-546.
- Coyle, S. D., Durborow, R. M. and Tidwell, J. H. (2004). *Anaesthetics in Aquaculture*. SRAC publication, Texas.
- Cunha, M. A., De Barros, F. M. C., Garcia, L. O., Veeck, A. P. L., Heinzmann, B. M., Loro, V. L., Emanuelli, T. and Baldisserotto, B. (2010). Essential oil of *Lippia alba*: A new anaesthetic for silver catfish, *Rhamdia quelen*. *Aquaculture*, 306 (1 – 4), 403 – 406
- Faanha, M. F and Gomes, L. C. (2005). A eficcia do mentol como anestsico para tambaqui (*Colossoma macropomum*, Characiformes: Characidae), *Acta Amazonica*, 35, 71–75.
- Feng, G., Zhaoang, P., Zhang, L., Kynand, B., Liu, J. and Huang, X. (2011). "Effects of anaesthetics MS-222 and clove oil on blood biochemical parameters of juvenile Siberian sturgeon, (*Acipenser baerii*)." *Journal of Applied Ichthyology*, vol. 27, pp. 595-599.
- Gonalves, A. F. N., Santos, E. C. C., Fernandes, J. B. K. and Takahashi, L. S. (2008). Mentol e eugenol como substitutos da benzocana na induo anestsica de juvenis de pacu. *Acta Sci. Anim. Sci.* 30(3): 339-344.
- Gressler, L. T., Silva, L.L. and Heinzmann, B.M. (2017). Anestsicos em animais aquticos. In: Baldisserotto, B., Gomes, L.C., Heinzmann, B.M., Cunha, M.A. (Eds.), *Farmacologia aplicada  aquicultura*. UFSM, Santa Maria. 1: 467-537.
- Husen, A. M. and Sharma, S. (2014). Efficacy of Anesthetics for Reducing Stress in Fish during Aquaculture Practices- A Review. *Journal of Science Engineering and Technology*, 10(1):104-123.
- Inoue, L. A. K., Santos, N. C. and Moraes, G. (2005).Clove oil as anaesthetic for juveniles of matrinx Brycon cephalus (Gunther, 1869), *Cincia Rural*, 33, 943–947.
- Iversen, M., Finstad, B., McKinlay, R. S. and Eliassen, R. A. (2003). The efficacy of metomidate, Clove oil, AQUI-STM and Benzoak1 as anaesthetics in Atlantic salmon (*Salmo salar* L.) smolts, and their potential stress-reducing capacity. *Aquaculture*, 221, 549-566.
- Javahery S., Nekoubin, H. and Moradlu, A. H. (2012). Effect of anaesthesia with clove oil in fish (review). *Fish Physiol. Biochem.* 38(6): 1545–1552.
- Keene, J. L. Noakes, D. L. G., Moccia, R .D. and Soto, C. G. (1998). The efficacy of Clove oil as an anaesthetic for rainbow trout *Oncorhynchus mykiss*. *Aquaculture Research*, 29, 89–101
- King, W., Hooper, B., Hillsgrave, S., Benton, C., and Berlinsky, D. (2005). The use of Clove oil, metomidate, tricaine methanesulphonate and 2-phenoxyethanol for inducing anaesthesia and their effect on the cortisol stress response in black sea bass (*Centropristis striata* L.). *Aquaculture Resources*, 36, 1442-1449.
- Kk, S. (2010). Efficacy of tricaine on *Peocilia latipinna* at different temperatures and concentrations. *African Journal of Biotechnology*, 9(5), 755-759.
- Maricchiolo, G. and Genovese, L. (2011). Some contributions to knowledge of stress response in innovative species with particular focus on the use of the anaesthetics. *The Open Marine Biology Journal*, 5(1): 24–33.
- Marking, L.L. and Meyer, F.P. (1985). Are better anaesthetics needed in fisheries?. *Fisheries*, 10(2): 2-5.
- Mitjana, O., Bonastre, C., Insua, D., Falceto, M. V., Esteban, J., Josa, A., and Espinosa, E., (2014). "The efficacy and effect of repeated exposure to 2-phenoxyethanol, clove oil and tricaine methanesulphonate as anesthetic agents on juvenile Angelfish (*Pterophyllum scalare*)." *Aquaculture (Amsterdam, Netherlands)*, vol. 433, pp. 491-495.
- Mylonas, C. C., Cardinaletti, G., Sigelaki, I. and Polzonetti-Magni, A. (2005). Comparative efficacy of Clove oil and 2- phenoxyethanol as anaesthetics in the aquaculture of European sea bass (*Dicentrarchus labrax*) and gilthead sea bream (*Sparus aurata*) at different temperatures. *Aquaculture*, 246, 467- 481.
- Okey, 1. B., Keremah, R. I. and Ofem, B. O. (2013). Effect of Clove (*Eugenia aromatica*) powder anaesthetic on some haematological parameters in hybrid catfish (*Heterobranchus bidorsalis* ϕ $\times$ *Clarias gariepinus* σ^7) juveniles. *International Journal of Fisheries and Aquaculture*, 5(7), 184-192.

- Okey, I. B. (2019). Anaesthetic Effects of clove (*Eugenia caryophyllata*) on Some Haematological and Biochemical Parameters of *Heterobranchus bidorsalis* Juveniles. *Journal of Fisheries and Aquaculture Research*, 4(1): 016-027.
- Okey, I. B., Keremah, R. I. and Gabriel, U. U. (2018). The efficacy of clove (*Eugenia caryophyllata*) powder as anaesthesia on African catfishes (*Clarias gariepinus* and *Heterobranchus bidorsalis*) fingerlings. *J Aquac Mar Biol*. 7(4):182–188.
- Palic, D., Herolt, D.M., Andreasen, C.B., Menzel, B.W. and Roth, J.A. (2006). Anaesthetic efficacy of tricaine methanesulfonate, metomidate and eugenol: Effects on plasma cortisol concentration and neutrophil function in fathead minnows (*Pimephales promelas* Rafinesque, 1820). *Aquaculture Research*, 254: 675-685.
- Ribeiro, A. S., Batista, E. S., Dairiki, J. K., Chaves, F. C. M. and Inoue, L. A. K. A. (2016). Anesthetic properties of *Ocimum gratissimum* essential oil for juvenile matrinxã. *Acta Sci. Anim. Sci.* 38(1): 1–7.
- Ross, L. G. and Ross, B. (1999) Anesthetic and sedative techniques for aquatic animals, 2nd edn, 159 p, Institute of Aquaculture, University of Stirling, Scotland, ackwell Science, Oxford, UK
- Ross, L. G. and Ross, B. (2008). Anaesthetic and sedative techniques for aquatic animals. 3rd Edition. Blackwell publishing.
- Sudagara, M., Mohammadizarejabada, A., Mazandarania, R. and Pooralimotlagha, S. (2009). The efficacy of Clove powder as an anaesthetic and its effect on haematological parameters on Roach (*Rutilus rutilus*). *Journal of Aquaculture feed science and nutrition*, 1(1), 1-5.
- Summerfelt, R. C. and Smith, L. S. (1990). Anaesthesia, surgery, and related techniques. In: Schreck, C.B., Moyle, P.B. (Eds.), *Methods for Fish Biology*. American Fisheries Society, Bethesda, MD., 213– 272.
- Taylor, P.W. and Roberts, S.D. (1999) Clove oil: an alternative anesthetic for aquaculture. *N. Am. J. Aquac.* 61: 150–155.
- Teixeira, R. R., Souza, R. C., Sena, A. C., Baldisserotto, B., Heinzmann, B. M., Couto, R. D. and Copatti, C. E. (2017). Essential oil of *Aloysia triphylla* in Nile tilapia: anaesthesia, stress parameters and sensory evaluation of fillets. *Aquac. Res.* 48(7): 3383–3392.
- Trushenski, J. T., Bowker, J. D., Cooke, S. J., Erdahl, D., Bell, T., MacMillan, J. R., Yanong, R. P., Hill, J. E., Fabrizio, M. C., Garvey, J. E. and Sharon, S. (2013). Issues regarding the use of sedatives in fisheries and the need for immediate-release options. *Transactions of the American Fisheries Society*, 142(2): 156-170.
- Velisek, J., Svobodova, Z., Piackova, V., Groch I, and Nepejchalova, I., (2005). Effects of Clove oil anaesthesia on common carp (*Cyprinus carpio* L.). *Veterinaria Medicinae of Czech*, 50 (6), 269–275.
- Velišek, J., Wlasov, T., Gomulka, P., Svobodová, Z., Novotny, L. and Ziomek, E. (2006). Effects of clove oil anesthesia on European catfish (*Silurus glanis*). *Acta Veterinarni Brno*, 75: 99- 106.
- Walsh, C. T. and Pease, B. C. (2002). The use of clove oil as an anaesthetics for the longfinned ell, (*Anguilla reinhardtii* Steindachner). *Aquaculture Research*, 33(8): 627-635.
- Wilfred-Ekprikpo, P. C. (2021). Evaluation of Mustard Seed (*Brassica nigra*) Powder as Anaesthetic Agents in Different Life Stages of Black Jaw Tilapia (*Sarotherodon melanotheron*). *Sumerianz Journal of Biotechnology*, 4 (2) 57-62.
- Woods, L.C., Theisen, D. D. and He, S. Y. (2008) Efficacy of aqua-S as an anesthetic for market-sized striped bass. *N. Am. J. Aquac.* 70 (2): 219-222.
- Yanar, M. and Kumlu, M (2000). The Anaesthetics Effects of Quinaldine Sulphate and/or Diazepam on Sea Bass (*Dicentrarchus labrax*) Juveniles. *Turkish Journal of Veterinary and Animal Science*, 25, 185-189.
- Zaikov, A., Iliev, I. and Hubenova, T. (2008). Induction and recovery from anaesthesia in pike (*Esox lucius* l.) exposed to clove oil. *Bulgarian Journal of Agricultural Science*, 14 (2): 165-170.

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Allied Aquaponics Technologies and Approaches

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Abstract

Aquaponics production has found a pride of place as one of the several green farming alternatives for simultaneous production of plants and fish. It is both eco-friendly and could help in sustainable agricultural development. The development of Aquaponics has led to different adaptations and allied technologies which are currently gaining research relevance. This is due to their importance and perceived advantages over conventional aquaponics system. The allied technologies include aeroponics which is the culture of plants parts or tissues using air/water fog. Algaeponics which encompasses the culture of microalgae in aquaponics system, taking advantage of their ability for nutrient uptake and consequently improvement in water quality. Also, aquaponics production of Marine and Brackish water adapted plants and fish known as Maraponics. The integration of Bioflux and Vermiponics with Aquaponics system was respectively advanced too. Both integrations could potentially improve water quality and performance beyond what is obtained in conventional aquaponic system. From this review therefore, there is still need to advance research in these allied aquaponics technologies and proposed new approaches through the combination of two or more existing aquaculture technologies. This is in a bid to meet aquaculture production in the current realities of the next industrial revolution.

Keywords: Aquaponics, Aquaculture, Water quality, Nutrients, Eco-friendly

Introduction

The word 'Aquaponics' is coined from the combination of two systems namely 'aquaculture' i.e., fish farming and 'hydroponics' i.e., growing plants without soil (Roosta and Hamidpour, 2011). Therefore, Aquaponics can be referred to as a food production system that uses nutrient-rich water from aquaculture production for the irrigation and fertilization of plants. The water from the hydroponics beds upon adsorption of nutrient imputed by the fish is recircled and returned to the fish rearing tanks (Rakocy et al., 2016). The concept of Aquaponics is therefore aimed at balancing the nutrients within a given system so that there will be less accumulation of excess nutrients (especially nitrogen). It should be noted that the main source of nutrient in the system are through the feed delivered, consumed, assimilated, and excreted by the fish (Rakocy & Hargreaves, 1993). The nutrients generated are however not only from fish manure, but also algae, and decomposing uneaten feed. The continuous accumulation of these nutrients without removal can otherwise build up to toxic and detrimental levels in the fish tanks. However, in the aquaponic system it serves as a source of liquid fertilizer which is usable for plants growth (Rakocy et al., 2004). Several key allied and alternative technologies to Aquaponics production system have been proposed in different studies. These technologies either expand or have the potential to improve the functionality, productivity, and efficiencies of the aquaponic production systems. Some may not be associated but are stand-alone technologies with integration with other systems as in the principle governing the aquaponics technology. The aim of these allied aquaponics alternatives has several things in common which is among other things to increase efficiency/productivity, reduce waste disposal, as well as reduce energy and water usage. The different allied aquaponics technology previously used are discussed herein.

Aeroponics

The definition proposed by Weathers and Zobel (1992), describes aeroponics as the culture of whole plants or it tissues using roots or whole tissue fed by an air/water fog as opposed to immersion in/on water, soil, nutrient agar or other substrates. For these researchers, plants that are grown partially with their roots in air and the other part in

nutrient solutions are aero-hydroponics in nature and not necessarily aeroponics. The same aero-hydroponics illustration is offered for plant grown at some point in air and in nutrient solution at another point. The advantages of this method included the ability of all year-round planting and harvesting without the fear of soil, pesticides, and residue contamination of the system. In addition, water usage and fertilizer application are significantly reduced (about 98% and 60% reduction respectively), while there is absolutely no need for the use of pesticide in this controlled system. Due to the increased ability of aeroponic plants to efficiently absorb more minerals and vitamins than those grown on conventional system, they are potentially healthier and more nutritious than plant originating from land/substrate-based system.

In aeroponics, as with hydroponics, nutrient supply can be optimized. The comparison of both systems reported by Hikosaka et al. (2014) noted similarities in the growth and harvesting quality of lettuce grown in both systems. However, this was not the same observation made for values of the rate of root respiration and photosynthesis of the leaves. In addition, the authors highlighted the fact that the system has lower water budget hence making it a more efficient system which is easier to manage than conventional hydroponics system (Hikosaka et al. 2014). The review paper by Lakhia et al. (2018) on the modern plant cultivation technologies in agriculture under controlled environments, considered aeroponics as the best plant growing method that can guarantee food security and sustainable development. Whilst several entrepreneurs, researchers, and hobbyists are propagating the idea of the combination of the aquaponics and aeroponics system, there are some key issues that must be resolved before it can gain its pride of place as a potential farming technology for the future. One of such issue is the name for the combined system. So far, aquaeroponics has been suggested and seem to be most appropriate for the system. Another aspect to consider is the potential for pathogens to grow in the airy wet environment; hence, more researches are needed to unravel these.

Algaeponics

Most unicellular photoautotrophs ranging from 0.2 µm up to 100 µm in size are known as Microalgae. They are found in most environments (including aquatic) and are classified into various taxonomic groups (Cuellar-Bermudez et al., 2015; Lee et al., 2017). Phytoplankton are responsible for over 45% of the primary production in the world and generate more than 50% of the atmospheric O₂ (Deppeler et al. 2018). The comparative advantage of macroalgae to larger plant is the small size which reduces the number of the internally competing physiological organelles, consequently, they are able to grow much faster than higher plants even in nutrient limited conditions (Gordon and Polle 2007; Moheimani et al. 2015). In addition, microalgae can efficiently utilize inorganic nutrients from waste effluents therefore their occasional use in wastewater treatment and bioremediation processes (Moheimani et al. 2012; Delrue et al. 2016; Ayre et al. 2017).

In conventional aquaculture and aquaponic systems; microalgae are normally not grown deliberately as it is a clear water aquaculture technology. Hence, they are seen as a nuisance capable of restricting the flow of water in the pipes, thereby leading to clogging. In addition, their respiration process and decomposition when they die off consume oxygen which can be a crisis especially at night. This could therefore attract insects and reduce the water quality to a large extent. However, in contrast to the above assumption and narrative, algae improved the water quality in the aquaponic system as it helps buffer the pH, increase dissolved oxygen, increased the production of polyunsaturated fatty acids as an addition fish feed supplement as well as add diversity / improve resilience to the system according to the observation in the study reported by Addy et al. (2017). Hence, this means that combining microalgae production with clear-water aquaponics system result in the provision of a part of the diet fed to fishes in the system. This has a lot of consequence for feeding and production cost, hence, future studies on this could focus on growing algae most probably in a separate loop in the aquaponics system to be fed as part of the diet to the fish.

Maraponics

When references are made to aquaponics system, it is most likely emphasis are largely towards freshwater grown plants and fish. However, with the limitation of freshwater resources for food production, and the continuous salinization of freshwater bodies occasioned by global warming (Turcios and Papenbrock 2014) the use of marine water in aquaponics system is beginning to gain relevance as an alternative farming system. The consideration of organisms for culture will therefore include euryhaline or saltwater fishes in combination with halophytic plants, seaweed and low salt-tolerant glycophytes (Joesting et al. 2016; Appelbaum and Kotzen 2016). Therefore, the term "Maraponics" has been coined for aquaponics systems that uses seawater or brackish water for the production of fish and plants (Gunning et al. 2016). Some studies have been reported in this regard with interesting results gotten. One of the earliest experiment on maraponics is by Langton et al. (1977) who successfully demonstrated that the red

seaweed, *Hypneamusiformis* can be cultured with saltwater shellfish effluents. Depending on the tolerance of the plant to salinity, the need to optimise brackish water levels for optimal performance of the plant is an area for future studies. Crops classified as glycophytes (i.e., low-moderate salt tolerance) like some tomatoes (*Lycopersicon esculentum* and *L. esculentum* var. *Cerasiforme*) and basil (*Ocimum basilicum*) could be produced in such mariponics system provided the salinity is about 4 g/L (4000 ppm). Other moderate salinity tolerant crops includes turnip, radish, cabbage, spinach, asparagus, cucumber etc. (Kotzen and Appelbaum 2010; Appelbaum and Kotzen 2016). Halophytes crops are however having high resistant to high salinities and includes broccoli (*Brassica oleracea italica*) and bell pepper (*Capsicum annuum*) (Dufault et al. 2001; Dufault and Korkmaz 2000).

Bioflux – Aquaponics Integration

Biofloc technology (BFT) is considered one of the most environmentally friendly technology of the twenty first century (Stokstad 2010). This is because the nutrients in the system can be continuously recycled by the action of different organisms and used within the system thereby expunging the need for water exchange (Avnimelech 2015). It utilizes heterotrophic bacterial in purification of water for Aquaculture production in zero water change setup. Hence, microorganisms play an important role in the BFT systems (Martinez-Cordoba et al. 2015). The maintenance of water quality, is done by controlling the bacterial community over autotrophic microorganisms through the manipulation of the carbon - nitrogen ratio (C:N) (Oladimeji et al., 2020). This is possible because nitrogenous by-products can be easily taken up by heterotrophic bacteria (Avnimelech 2015; Emerenciano et al. 2017). Since the science behind Aquaponics system is simply the closed integration of re-circulatory aquaculture system with hydroponics system; the incorporation of biofloc therefore makes it impossible to maintain a clear water setup in such a modified aquaponic system.

A couple of studies have been reported on the integration of BFT in an aquaponics system. The finding of Pinho et al. (2017) showed that plant and fish yields were improved in addition to better plant visual quality when the BFT-Aquaponics technology was compared to other conventional recirculatory aquaculture systems. However, this opinion wasn't collaborated by the research findings of Rahman (2010) and Pinho (2018) as the authors observed a similar and low performance of fish and crops in the integrated system compared to conventional aquaculture systems. As research detail more in this aspect, there are a few thing to have in mind; One of which is the name for the name for the BFT – Aquaponics integration. A number of person have suggested Bioaponics system, however this word has already been coined for another system whose system of operation differ completely from the current BFT – Aquaponics integration narrative. Floponics may be a better alternative for the nomenclature of the novel system discussed. Also, since Aquaponics system requires basically five components, namely; fish tank, hydroponic tanks, settling tanks, Sump and biofilters, the incorporation of biofloc technology could make irrelevant the need for the last three components of the aquaponics system meant for water treatment. This could be an element of future research.

Vermiponics and Aquaponics

This section encompasses the use of detritivore invertebrates (earthworms) in the aquaponics production system because of their ability to convert organic waste into fertilizer. It has been reported that Aristotle, Charles Darwin as well as the philosophers Pascal and Thoreau were intrigued by worms and the way that they digest matter hence they took interest in these detritivore invertebrates (Adhikary 2012) and they were protected by law under Cleopatra. The importance of earthworms in agricultural and horticultural activities cannot be over emphasised as they improve soil health through their activities of transporting bottom nutrients and minerals to the surface (National Geographic). The deliberate rearing of worm is known as vermiculture and the modern history dates back as early 1970s and 1980s when Mary Appelhof started writing scientifically on the worms. When earthworms are introduced into the aquaponic system, it has been suggested to be called 'vermi-aquaponics' to differentiate the systems. However, vermiquaponics system could be a better name for such system as it takes into consideration the two different systems integrated together, namely, vermiponics and aquaponics. Vermiquaponics is thus the introduction of earthworms into the growing plant troughs of the aquaponic system. It should be noted that vermiquaponics system technology is still not well developed as it is currently limited to practice by hobbyists and components of a few research laboratories. Just like the algaeponics system, worms raised in the vermiquaponics system could result in the provision of apart of the diet that can be fed to fishes in the system. This is because worms can be eaten directly by fish hence, this supplementary feeding source can help reduces significantly the feeding and production cost.

Conclusion

Despite some perceived advantages of many of the novel allied technologies discussed in this review, they have been limited in scope and not largely popularized due to the paucity of information on their workability. This is

basically because research in these areas is still at infancy compared to conventional Aquaponics production systems. It is believed that with more researchers working on these technologies, they can be developed into futuristic technologies for food production with ability for high efficiencies.

References

- Addy MM, Kabir F, Zhang R, Lu Q, Deng X, Current D, Griffith R, Ma Y, Zhou W, Chen P, Ruan R (2017) Co-cultivation of microalgae in aquaponic systems. *Bioresour Technol* 245 (2017):27–34
- Adhikary S (2012) Vermicompost, the story of organic gold: a review. *Agricult Sci* 3(7). <https://doi.org/10.4236/as.2012.37110>
- Appelbaum S, Kotzen B (2016) Further investigations of Aquaponics using brackish water resources of the Negev Desert. *Ecocycles Scientific J Eur Ecocycl Soc* 2(2):26–35. ISSN 2416-2140 <https://doi.org/10.19040/ecocycles.v2i2.53>
- Avnimelech Y (2015) Biofloc technology: a practical guide book, 3rd edn. The World Aquaculture Society, Baton Rouge
- Ayre JM, Moheimani NR, Borowitzka MA (2017) Growth of microalgae on undiluted anaerobic digestate of piggery effluent with high ammonium concentrations. *Algal Res* 24:218–226
- Cuellar-Bermudez, S. P., Aguilar-Hernandez, I., Cardenas-Chavez, D. L., Ornelas-Soto, N., Romero-Ogawa, M. A. and Parra-Saldivar, R. (2015). Extraction and purification of high-value metabolites from microalgae: essential lipids, astaxanthin and phycobiliproteins. *Microbial biotechnology*, 8(2): 190-209.
- DelrueF, Ivarez-D az PD, Fon-Sing S, Fleury G, Sassi JF (2016) The environmental biorefinery: using microalgae to remediate wastewater, a win-win paradigm. *Energies* 9(3):132
- Deppeler S, Petrou K, Schulz KG, Westwood K, Pearce I, McKinlay J, Davidson A (2018) Ocean acidification of a coastal Antarctic marine microbial community reveals a critical threshold for CO₂ tolerance in phytoplankton productivity. *Biogeosciences* 15(1):209–231
- Dufault RJ, Korkmaz A (2000) Potential of biosolids from shrimp aquaculture as a fertiliser in bell pepper production. *Compost Sci Util* 3:310–319
- Dufault RJ, Korkmaz A, Ward B (2001) Potential of biosolids from shrimp aquaculture as a fertiliser for broccoli production. *Compost Sci Util* 9:107–114
- Emerenciano MGC, Mart nez-C rdova LR, Mart nez-Porchas M, Miranda-Baeza A (2017) Biofloc technology (BFT): a tool for water quality management in aquaculture, water quality, In: Hlanganani Tutu (ed). InTech
- Gordon, J. M., &Polle, J. E. (2007). Ultrahigh bioproductivity from algae. *Applied microbiology and biotechnology*, 76(5), 969-975.
- Gunning D, Maguire J, Burnell G (2016) The development of sustainable saltwater-based food production systems: a review of established and novel concepts. *Water* 8(12):598. <https://doi.org/10.3390/w8120598>
- Hikosaka Y, Kanechi M, Uno Y (2014) A novel aeroponic technique using dry-fog spray fertigation to grow leaf lettuce (*Lactuca sativa* L. var. *crispa*) with water-saving hydroponics. *Adv Horti Sci* 28(4):184–189
- Joesting HM, Blaylock R, Biber P, Ray A (2016) The use of marine aquaculture solid waste for nursery of salt marsh plants *Spartina alterniflora* and *Juncus roemerianus*. *Aquac Rep* 3:108–114
- Kotzen B, Appelbaum S (2010) An investigation of aquaponics using brackish water resources in the Negev Desert. *J Appl Aquacult* 22(4):297–320. ISSN 1045-4438 (print), 1545-0805 (online). <https://doi.org/10.1080/10454438.2010.52757>
- Lakhia IA, Gao J, Naz ST, Chandio FA, Buttar NA (2018) Modern plant cultivation technologies in agriculture under controlled environment: a review on aeroponics. *J Plant Interact* 13 (1):338–352. <https://doi.org/10.1080/17429145.2018.1472308>
- Langton RW, Haines KC, Lyon RE (1977) Ammonia nitrogen produced by the bivalve mollusc *Tapes japonica* and its recovery by the red seaweed *Hypnea musciformis* in a tropical mariculture system. *Helgol Wiss Meeresunters* 30:217–229
- Lee, S. Y., Show, P. L., Ling, T. C. and Chang, J. S. (2017). Single-step disruption and protein recovery from *Chlorella vulgaris* using ultrasonication and ionic liquid buffer aqueous solutions as extractive solvents. *Biochemical engineering journal*, 124: 26-35.
- Lenz GL, Durigon EG, Lapa KG, Emerenciano MGC (2017) Produção de alface (*Lactuca sativa*) em efluentes de um cultivo de tilápia em sistema BFT em baixa salinidade. *Bol Inst Pesca* 43:614–630
- Martnez-Cordova LR, Emerenciano M, Miranda-Baeza A, Martnez-Porchas M (2015) Microbial based systems for aquaculture of fish and shrimp: an updated review. *Rev Aquac* 7(2):131–148
- Moheimani NR, Parlevliet D, McHenry MP, Bahri PA, de Boer K (2015) Past, present and future of microalgae cultivation developments. In: Biomass and biofuels from microalgae. Springer, Cham, pp 1–18

- Moheimani NR, Webb JP, Borowitzka MA (2012) Bioremediation and other potential applications of coccolithophorid algae: a review. *Algal Res* 1(2):120–133
- Neori A, Shpigiel M, Ben-Ezra D (2000) A sustainable integrated system for culture of fish, seaweed, and abalone. *Aquaculture* 186:279–291
- Pinheiro I, Arantes R, Santo CME, Seiffert WQ (2017) Production of the halophyte *Sarcocorniaambigua* and Pacific white shrimp in an aquaponic system with biofloc technology. *EcolEng* 100:261–267Rahman (2010),
- Pinheiro, I. C. (2021). Estratégias de produção de camarãozinho e salicorniaemaquaponia com bioflocos
- Pinho SM (2018) Tilapia nursery in aquaponics systems using bioflocs technology. A thesis presented at aquaculture Centre of Sao Paulo State University. Degree of Master of Science, Jaboticabal, Sao Paulo, Brazil, February 2018
- Rahman SSA (2010) Effluent water characterization of intensive Tilapia culture units and its application in an integrated lettuce aquaponic production facility. A thesis submitted to the graduate faculty. Auburn University, Degree of Master of Science, Auburn Alabama, December 13 2010
- Rakocy JE (2012) Aquaponics – integrating fish and plant culture. In: Tidwell JH (ed) *Aquaculture Production Systems*, 1st edn. Wiley-Blackwell, Oxford, pp 343–386
- Rakocy JE, Bailey DS, Shultz C, Thoman ES 2004: Update on tilapia and vegetable production in the UVI aquaponics system. *Proceedings from the 6th International Symposium on Tilapia in Aquaculture*. 2 676-690.
- Rakocy, J. E., & Hargreaves, J. A. (1993). Integration of vegetable hydro-ponics with fish culture: A review. In *Techniques for modern aquaculture*, proceedings aquacultural engineering conference (pp. 112–136). St. Joseph, MI: American Society of Agricultural Engineers.
- Rakocy, J.E., M.P. Masser, and T.M. Losordo. 2016. Recirculating aquaculture tank production systems: aquaponics- integrating plant and fish culture. *Oklahoma Coop. Ext. Serv. SRAC-454*
- Rocha AF, Biazetti Filho ML, Stech MR, Silva RP (2017) Lettuce production in aquaponic and biofloc systems with silver catfish *Rhamdiaquelen*. *Bol Inst Pesca* 44:64–73
- Roosta, H. R., &Hamidpour, M. (2011). Effects of foliar application of some macro-and micro-nutrients on tomato plants in aquaponic and hydroponic systems. *Scientia Horticulturae*, 129(3), 396-402.
- Stokstad E (2010) Down on the shrimp farm. *Science* 328:1504–1505
- Turcios AE, Papenbrock J (2014) Sustainable treatment of aquaculture effluents – what can we learn for the past for the future? *Sustainability* 6:836–856
- Weathers PJ, Zobel RW (1992) 1992, *Aeroponics for the culture of organisms*. *Tissues Cells Biotechnol Adv* 10(1):93–115

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Construction of Receptacles for the Spontaneous Spawning of Silver Catfish (*Chrysichthys nigrodigitatus*)

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Abstract

Parental stock of *Chrysichthys nigrodigitatus* with average weight of 338.32g and 536.38g for the females and males respectively were obtained from the wild, for the purpose of spawning evaluation using bamboo and Polyvinyl Chloride (PVC) receptacles. The constructed receptacles measured 0.75m in length and 0.1m in diameter for the Polyvinyl Chloride pipes, while the bamboo stems were 0.75m in length and 0.08 - 0.09m in diameter. The study duration was for a period of ten weeks. Results of the study indicated that both bamboo and PVC receptacles triggered spontaneous spawning in paired sexually mature silver catfish with egg production ranging from 950 to 1500 per receptacle and percentage spawning successes at 25% and 75% respectively for PVC and bamboo receptacles. It was concluded that the presence of receptacles was a very essential step in the spontaneous spawning and production of silver catfish in captivity.

Key words: Silver catfish, *Chrysichthys nigrodigitatus*, Parental stock, Spawning, Receptacles

Introduction

Fisheries and aquaculture resources constitute one of the world's largest sources of animal protein. Fisheries are crucial to global food security and nutrition, and they offer development pathways to contribute to a more prosperous, peaceful and equitable world (FAO, 2020). It is estimated that over 10 million Nigerians are engaged in primary and secondary fisheries activities and a host of other ancillary actors derive their livelihoods from the fisheries sub sector (Oladimeji, 2018). It is pertinent to note that Nigeria is a typical coastal country endowed with a coastline of about 800 km, a continental shelf of about 256,000 km²; exclusive economic zone area of 210,900 km² and marine area of 46,000 km² (Ita, 1985, Oladimeji, 1999). The country is also blessed with over 14 million hectares of reservoirs, lakes, ponds and major rivers capable of producing over 980,000 metric tons of fish annually (FDF, 2007).

However, as stated by Oladimeji (2018), there is a persisting paradox of a rich country inhabited by poor people which has been of great concern for many years. It is therefore necessary that outputs of research leads to diversification of culturable fishes, such as the silver catfish. *Chrysichthys nigrodigitatus* parent stock can safely be retrieved from Nigeria's water bodies, both freshwaters and brackish waters (Nwafili *et al.*, 2015), using different traps (Anwa-Udondiah *et al.*, 2014) for the purpose of propagation (Anwa-Udondiah, 2017) which would generate employment as well as contribute to the creation of wealth and improve standard of living for stakeholders. The research objective was to evaluate the effectiveness of utilizing natural and artificial objects, i.e. bamboo and PVC as spawning receptacles in tanks for silver catfish parent stock.

Materials and Methods

Preparation of spawning systems – Four 2 m³ capacity plastic tanks were filled with 1 m³ of water each.

Construction and deployment of receptacles – Two types of receptacles shown in Plate I comprising Polyvinyl Chloride pipes (length = 0.75 m; diameter = 0.1 m) and bamboo stems (length = 0.75 m; diameter = 0.08 - 0.09 m) were constructed. One end of the cut-to-size PVC pipes were covered with cap plugs which had been drilled through with holes on their flat ends to facilitate draining of water while keeping in fish or reproductive products. Likewise, the bamboo receptacles were plugged at one end with *Luffacy lindrica*, a naturally occurring sponge gourd growing in close proximity to the experimental site located at Nigerian Institute for Oceanography and Marine Research, Badore, Lagos. The receptacles were also then attached with 1.5 meter ropes on their opposite ends and deployed as indicated in Plate I. In total, eight receptacles were constructed consisting of four cut PVC pipes and four cut

bamboo stems.

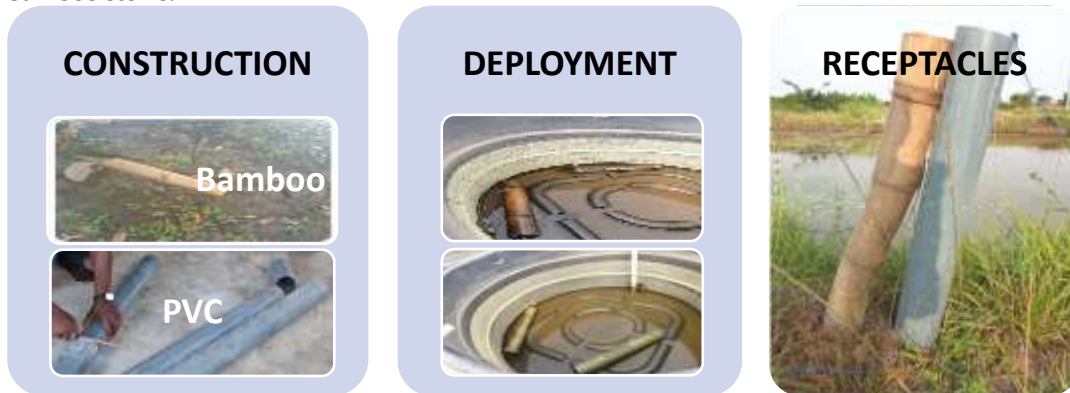


Plate I: Construction and deployment of bamboo and PVC breeding receptacles

Collection of silver catfish parent fish – A field trip was taken to Lagos Lagoon at Epe axis for collection. Two dug-out canoes were paddled towards the mangrove fringes where passive traps had previously been set for retrieval of male and female catfish pairs. Bottom-set drums with non-return valves and large sized bamboo passive traps used in the artisanal fishery of *Chrysichthys spp.* were pulled out of the lagoon and tilted towards the boat for collection as depicted in Plate II.



Plate II: *C. nigrodigitatus* collection

Transportation to NIOMR, Badore – Four doubled polyethylene oxygen bags containing well water collected in close proximity to the lagoon were infused with oxygen and utilized for conveyance by placing eight fish of the same sex in each doubled bag. The tops of the bags were twisted and secured tightly with rubber bands to prevent escape of oxygen or pouring out of water.

Biometric indices – On arrival, weight and length measurements were carried out with Mettler Toledo electronic balance - ME1002E to the nearest 0.01g and Wildco® fish measuring board – Model # 118-B30 to the nearest mm respectively. Female parental stock averaged 338.32 g, 22.83 cm, 25.20 cm and 29.98 cm for initial mean weight, standard length, fork length and total length respectively while male parental stock averaged 536.38 g, 26.90 cm, 29.56 cm and 33.85 cm for initial mean weight, standard length, fork length and total length respectively.

Experimental set-up and design for the spawning trials evaluation – The experimental set-up consisted of four plastic tanks each having either two bamboo receptacles or two PVC receptacles. Each duplicated experimental unit received two male and two female silver catfish.

Data collection – The breeding pairs in the units were checked fortnightly until termination of study at week 10.

Results and Discussion

Silver catfish pairing ratio of 1:1 per receptacle is as indicated in Plate III. The presence of hollow receptacles initiated pairing behavior and subsequently, spontaneous spawning by the breeding pairs in some of the units which appeared to be an important external environmental cue to trigger internal mechanisms thereby culminating in the observed final event of the release of fertilized eggs presented in Plate IV. Production ranged from 950 to 1500 eggs per receptacle.

Evidence had been obtained from previous works documenting the factor which stimulates *C. nigrodigitatus* to spawn in a controlled environment (Hem, 1986; Anyanwu, 1988; Otémé, 1993; Kouamé et al., 2014), however, inferences were drawn from utilizing only hollow receptacles made from PVC pipes usually with confinement of paired fish within the pipes which were usually 0.3 m in diameter and closed at both ends.

The efficacy, absolute frequency and percentage of both types of receptacles for use in *C. nigrodigitatus* captive production are presented in Table 1. Spawning successes were 25% and 75% for PVC and bamboo receptacles respectively



Plate III: Paired female and male *C. nigrodigitatus*



Plate IV: Cut out bamboo showing eggs

Table 1: Absolute frequency and percentage of spawnings per treatment

TREATMENT	RATE	PERCENT
TI [Bamboo]	3	75
TII [PVC]	1	25
N = 16		

Conclusion

The presence of receptacles, whether of a natural or artificial substance, is a very essential step in initiating pairing behavior which is a precursor to spontaneous spawning and production of silver catfish in captivity.

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References

- Anwa-Udondiah, E. P., Anyanwu, P. E. and Akintayo, I. A. (2014). Efficiency of Different Traps for Silver Catfish Fishery and its Aquaculture Implications in the Face of Climate Change. *Journal of Fisheries and Aquatic Science*. 9 (4): 205-212.
- Anwa-Udondiah, E. P. (2017). Breeding, embryological development and larval rearing of the silver Catfish, *Chrysichthys nigrodigitatus* (Lacépède, 1803). Ph. D. Dissertation. Ahmadu Bello University, Zaria. 155 pp.
- Anyanwu, P. E. 1988. Report on 6-weeks training programme in aquaculture at Centre de Recherches Océanographiques (C.R.O.), Abidjan. 18th March – 25th April, 1988.
- FAO. (2020). The State of World Fisheries and Aquaculture 2020. Sustainability in Action. Rome. 224pp.
- FDF. (2007). Fishery Statistics of Nigeria. Federal Department of Fisheries Publication. Abuja, FCT, Nigeria. 11-24 pp.
- Hem, S. (1986). First results of controlled reproduction of *Chrysichthys nigrodigitatus* in fish culture, p. 189-205. In E. A. Huisman (ed.) *Aquaculture research in the Africa region*. Pudoc, Wageningen, The Netherlands. 274 p.
- Ita, E. O. (1985). Investment Prospect in Inland Capture Fisheries with special reference to Small Reservoirs. The Exclusive Fishing Right License Model. Kainji Lake Research Institute Technical Report, Series No. 14. 1985. 27-44.
- Kouamé, A., Koco, N. C. S. and Laurent, A. Y. (2014). Aquacultural potential of silver catfish *Chrysichthys nigrodigitatus* (Lacépède, 1803) bred in fresh and brackishwater in three rearing systems: Enclosures, cement tanks and earth ponds. *Advances in BioResearch*. 5 (2): 165-171.

- Nwafili, S. A., Guijing, R. and Xiang, G. T. (2015). Microsatellite analysis of six populations of *Chrysichthys nigrodigitatus* from Nigeria. *Annual Research & Review in Biology*. 5 (6): 544-552.
- Oladimeji, Y. U. (1999). An Economic Analysis of Artisanal Fisheries in Kwara State, Nigeria. M. Sc. Thesis. Federal University of Technology, Akure, Nigeria. 71pp.
- Oladimeji, Y. U. (2018). Assessment of trend of artisanal fish production in Nigeria vis-à-vis implications on economic growth. *Nigerian Journal of Fisheries and Aquaculture*. 6 (1): 37-46.
- Otémé, Z. J. (1993). Reproduction and fecundity of the catfish *Chrysichthys nigrodigitatus* in captivity. *Journal Ivoirien d'Océanologie et de Limnologie*. 2 (1): 53-59.

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Growth Pattern of *Clarias gariepinus* Cultured in Concrete Tanks for 14 Weeks and its Effects on the Water Quality of the Culture System

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Abstract

A study to investigating the growth pattern of *Clarias gariepinus* and its effects on water quality in a culture system was carried out in two concrete tanks measuring 5 m x 2 m x 2.5 m (25 m³). The result revealed that weight gains vary with culture periods. There were three peaks (week 3, week 6 and week 9). The different peaks represents points high weight gain rate. The highest mortality was recorded at week 8 with rising weight gain and ammonia was in its highest. This could be as a result of metabolic activities going on in the culture tanks. The increase in weight gain seen in the two tanks within the same weeks in an indication of better growth performance within these weeks. A confirmatory study need to be carried out for this observation. From the result, there was an indication that there was a relationship between the weight gain and the ammonia build up in the culture system.

Keywords: Growth pattern, Concrete tanks and Water quality

Introduction

There is an increased global attention on Aquaculture because of the need to augment fish production from the wild. This is noticeable in country like Nigeria with high protein demand. The protein requirements of most countries cannot be adequately met by poultry and live stocks food. Poultry products are more expensive than fish and beef have been implicated in heart disease. Fish is generally cheap, rich in protein and high in poly unsaturated fat which gives it medical or health recommendation (Balogun, 1998; Ziaeeian, *et al.*, 2008 and Widjaja, *et al.*, 2009). Culture of fish in Nigeria is high because of awareness of aquaculture, availability of large and cheap water, strong interest of providing food and making profit (Owodeinde and Ndimele, 2011).

The most popular culturable fish species in Nigeria and other parts of Africa are members of catfish family called Clariidae. *Clarias gariepinus* and *Heterobranchus sp* are the two commonly cultured Clariid fish (Ojutiku, 2008). They are very popular among fish farmers and consumers alike. They are reared all over the country and have very good commercial value in Nigeria markets (Adewolu and Adoti, 2010). The preference as cultured species is due to several factors which include fast growth rate, high resistance to disease, tolerance to adverse environmental conditions, ability to feed on wide range of feed and capacity to withstand low pH and oxygen (Fegbenro, *et al.*, 1992). It also has high feed efficiency and utilization (Adebayo and Olanrewaju, 2000).

The profitability of aquaculture industry is becoming widely known in the last decade (Huda *et al.*, 2002). Aqua-feed has been a setback to aquaculture profitability, according to Agung (2004), feed cost accounts approximately 40 – 60% of the operating cost in aquaculture. The economic viability of aquaculture depends on the availability and quality of aqua-feed.

The knowledge of growth pattern will further help fish farmers in the management of their culture fish in terms of water quality and feeding. This study is design to investigate the growth pattern of *C. gariepinus* and its effects on water quality of the culture system.

Materials and Methods

Study on the growth pattern of *Clarias gariepinus* in concrete tanks measuring 5 m x 2 m x 2.5 m (25 m³)each and its effects on water quality of the culture system was carried out at Badore fish farm, NIOMR. One thousand fingerlings of average weight of 8.26 g were purchased from a reputable farm at Ikorodu, Lagos and were transported to Badore through water in black vats without aeration. On getting to the farm, the fingerlings were acclimatized for two days to enable them stabilize before feeding. The stocking density was 20 fingerling/ m³ in two tanks (plate 1).



Plate 1: counting fingerlings for tank stocking

The fish were feed 10% body weight for 6 weeks, 5% body weight for 6 weeks and 2% body weight for two weeks before sales. Sorting was done once every month (plate 2).



Plate 2: harvesting fish for sorting



Plate 3: sorting fish on the sorting table

Sampling of fish was done once in two weeks (Plate 4). The data collected was used to calculate the performance of the fish using the following: specific growth rate (SGR), weight gain (WG), daily weight gain (DWG), feed conversion ratio (FCR), mean weight gain (MWG), using the following equations:

$$MWG = W_f - W_i$$

Where W_f is the mean final weight and W_i the initial weight. (Adewunmi, 2006).

$$DWG = \frac{MWG}{D}$$

Where D is the rearing period (days)

Where D is the rearing period (days)

$$\text{Feed conversion ratio (FCR)} = \frac{\text{feed intake (dry weight in g)}}{\text{Fish wet weight gain (g)}}$$



Plate 4: sorting of fish

The water parameters were monitored bi weekly using Lamotte (freshwater aquaculture test kit) model AQ – 2 for dissolve oxygen, pH, tape rule to measure the length, weighing balance for the weight and mercury in glass thermometer for temperature.

Data collected were analyzed using one-way analysis of variance in a completely randomized design. Significant means were separated using Duncan Multiple range test.

Result and Discussion

The total quantity of feed given was 900kg while the total final weight was 505.33kg. The Fig. 1. below show the weekly growth rate of the fish.

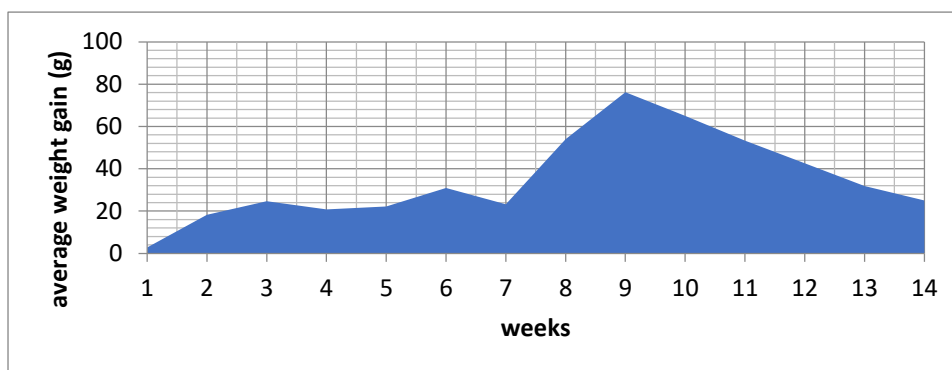


Fig. 1. Weekly average weight gain, average daily weight gain and weekly feed conversion rate for fourteen weeks

The result showed in fig. 1 revealed that weight gains vary with culture periods. From the fig.1 above, there were three peaks (week 3, week 6 and week 9). The different peaks represents points high weight gain rate. This implies that during the 14 weeks culture period, there were three peak points which is followed with reduction of average weight gain. There was reduction in weight gained in week 4, 7 and 10. According to Eriegha and Ekokotu (2017), growth potential differ across fish species and it is highly dependent on some factors such as feed intake and on how well the feed has been adjusted to the nutritional needs of the fish. The quality of the feed can influence its intake by the fed fish and management of water quality variables (Thorpe and Cho, 1995; Talbot et al., 1999; White, 2013).

Table 1. The average weight gain (AWG), average daily weight gain (ADWG), Feed conversion ratio (FCR), Mortality, and water physico-chemical parameters

Weeks	AWTG (g)	ADWTG (g)	FCR	Morta.	pH	(NH ₃)	(NO ₂)	Temp. °C
1	2.3± 1.23	0.40± 0.01	1.89±0.20	Nil	7±0.18	0.2±0.001	0.00	30.0±0.06
2	18.26±1.18	2.61±0.06	1.01±0.07	Nil	7±0.16	0.2±0.004	0.00	29.8± 1.04
3	24.67±1.43	3.52±0.07	1.01±0.04	7±0.16	7±0.10	2.0±0.015	0.00	29.9±1.08
4	20.80±1.33	2.97±0.01	1.70±0.12	Nil	7±0.16	0.2±0.004	0.00	30.0±1.11
5	22.19±1.35	3.17±0.08	2.01±0.15	2±0.17	7±0.17	0.4±0.002	0.00	29.9±1.05
6	30.93±1.20	4.42±0.06	2.24±0.10	2±0.16	7±0.19	0.3±0.019	0.00	29.3±1.10
7	23.23±1.52	3.32±0.07	3.40±0.18	3±0.15	7±0.17	0.3±0.017	0.00	29.8±1.09
8	53.88±1.44	9.14±0.10	1.51±0.14	10±0.19	7±0.55	0.5±0.01	0.00	30.0±1.10
9	76.20±1.57	10.89±0.18	1.74±0.18	3±0.20	7±0.20	0.3±0.02	0.00	30.0±0.18
10	65.00±1.64	9.29±0.20	2.24±0.16	1±0.12	7±0.23	0.2±0.02	0.00	29.7±1.12
11	53.30±1.70	7.61±0.51	2.63±0.20	1±0.16	7±0.40	0.3±0.01	0.00	30.2±1.06
12	42.61±1.92	6.09±0.28	3.63±0.19	2±0.18	7±0.29	0.4±0.02	0.00	29.7±1.14
13	31.85±1.75	4.48±0.48	3.75±0.19	1±0.11	7±0.20	0.3±0.02	0.00	29.8±1.20
14	25.03±1.88	3.58±0.38	3.80±0.15	1±0.09	7±0.33	0.4±0.02	0.00	29.8±1.19

Studies have shown that growth of fish in aquaculture mainly depends on feed consumption and quality (Slawski *et al.*, 2011); stocking density (Ma *et al.*, 2006); biotic factors such as sex and age (Imsland and Jonassen, 2003); genetic variance; and abiotic factors such as water chemistry, temperature (Imsland *et al.*, 2007), photoperiod (Imsland and Jonassen, 2003), and oxygen level (Bhatnagar and Devi, 2013). Therefore, successful management of fish requires an understanding of water quality, which is determined by abiotic factors such as temperature, dissolved oxygen (DO), transparency, carbon dioxide, pH, alkalinity, hardness, unionized ammonia, nitrite, nitrate, primary productivity, biological oxygen demand (BOD), plankton population among others (Bhatnagar and Devi, 2013). Kawshik and Cowey, (1990) described that ammonia excretion rates are directly related to dietary nitrogen content and protein intake. Excessive ammonia can cause the growth performance decrease, tissue erosion and degeneration, immune suppression, and high mortality in aquatic animals, which acts as toxicity by increasing ammonia levels in blood and tissues (Lemarie *et al.* 2004; Li *et al.* 2014). The ammonia recorded in this study was higher than the permissible limit of < 0.1ppm by Boyd, (1998), but lower than 9 – 14.2 ppm recorded by Abo-Esa (2008) as shown in table 1.

From table one, the highest mortality was recorded at week 8 with rising weight gain and ammonia was in its highest. This could be as a result of metabolic activities going on in the culture tanks. The increase in weight gain seen in the two tanks within the same weeks in an indication of better growth performance within those weeks. A confirmatory study need to be carried out for this observation. From the result, there was an indication that there was a relationship between the weight gain and the ammonia build up in the culture system.

Conclusion

For aquaculture to be sustained at a more profitable level, the growth pattern of this fish needs to be carefully studied. This will help farmers know when to intensify the water management of their culture system since the rapid weight gain might also lead to rapid water pollution due to high rate of metabolism.

Recommendations

This study was carried out in production tank system. A more carefully designed laboratory investigation will be needed to confirm some of the observations made in this study.

References

- Abo-Esa, J. F. K. (2008) Study on some Ectoparasite Disease of Catfish, *Clarias gariepinus* with their control by Ginger, Zingiberofficiale. Mediterranean Aquaculture journal, 1 (1) p. 1 – 10.
- Adebayo, O. T and Olanrewaju, J. O. (2000), Reproductive performance of African catfish, *Heterobranchus bidorsalis* under different feeding regimes. Proceeding of the 6th International Symposium of Reproductive Physiology of Fish, July, 1999, Institute of Marine Research and University of Bergen, Norway. P 4-9.
- Adewumi, A. A. (2006), The growth and gonadal maturation of African catfish. *Clarias gariepinus* (Burchell) broodstock fed differently heated soybean-based diets. Aquaculture Nutrition. 12: 267-274.
- Adewolu, M. A. and Adoti, A. J. (2010) Effect of mixed feeding schedules with varying dietary crude protein levels on the growth and feed utilization of *Clarias gariepinus* (Burchell, 1822) fingerlings. *J. Fish. Aquat. Sci.*, 5: 304 – 310
- Agung, S (2004). Comparism of Lupin meal based diets cost efficiency for juvenile *Penaeus monodon* tested under pond conditions. *J. Coastal Dev.*, 8(1): 47–51.
- Balogun, A. M. (1998). The sanctity of fish as food. Inaugural lecture series 14. Federal University of Technology Akure, Ondo State. 79pp.
- Bhatnagar, A, and Devi, P. (2013) Water quality guidelines for the management of pond fish culture. *Int J Environ Sci.* 3(6):1980–2009. <https://doi.org/10.6088/ijes.2013030600019>.
- Boyd, C. E. (1998) Water Quality for Pond Aquaculture, Alabama Aquaculture Experiment Station, Auburn University, Alabama.
- Eriegha, O. J. and Ekokotu, P. A. (2017) Factors affecting feed intake in cultured fish species: A Review. *Animal Research International.* 14(92) p 2697 – 2709.
- Fagbenro, O. A. Balagon, A .M. and Anyanwu, C. N. (1992). Optimum dietary protein level of *Heterobranchus bidorsalis* fed compounded diet. *Nig. J. Appl. Fish. Hydrobiol.* 1: 41-45
- Imsland, A.K. and Jonassen, T.M. (2003) Growth and age at first maturity in turbot and halibut reared under different photoperiods. *Aquac Int.* 11:463–75.

- Imsland, A. K., Schram, E., Roth, B., Schelvis-Smit, R. and Kloet, K. (2007) Growth of juvenile turbot *Scophthalmus maximus* (Rafinesque) under a constant and switched temperature regime. *Aquac Int.* 15:403–7.
- Kaushik, S. J and Cowey, C. B. (1990) Dietary factors affecting nitrogen excretion by fish. In Cowey, C. B. and Cho, C. Y. (Eds). *Nutritional Strategies and Aquaculture Waste*. Proceeding of First International Symposium on Nutritional Strategies in Management of Aquaculture Waste, Ontario, 5 – 8 June, University of Guelph, Canada. P 3 – 19.
- Lemarie, G., Dosdat, A., Coves, D., Dutto, G., Gasset, E. and Person-Le Ruyet, J. (2004) Effect of chronic ammonia exposure on growth of European seabass (*Dicentrarchus labrax*) juveniles. *Aquaculture*. 229(1-4):479–91.
- Li M, Yu N, Qin JG, Li E, Du Z, Chen L. (2014) Effects of ammonia stress, dietary linseed oil and *Edwardsiella ictaluri* challenge on juvenile darkbarbel catfish *Pelteobagrus vachelli*. *Fish and Shellfish Immunology*. 38(1):158–65.
- Ma A, Chen C, Lei J, Chen S, Zhuang Z, Wang Y. (2006) Turbot *Scophthalmus maximus*: stocking density on growth, pigmentation and feed conversion. *Chin J Oceanol Limnol.* 24:307–12.
- Owodeinde, F. G and Ndimele, P. E. (2011). Survival, growth and feed utilization of two clariid catfish (*Clarias gariepinus*, Burchell, 1822 and *Heterobranchus bidorsalis*, Geoffroy, 1809) and their reciprocal hybrids. *J. Applied Ichthyol.*, 27: 1249 – 1253.
- Ojutiku, R. O. (2008). Comparative survival and growth rate of *Clarias gariepinus* and *Heterobranchus* hatchlings fed live and frozen daphnia. *Pak. J. Nutr.*, 7: 527 – 529
- Slawski, H., Adem, H., Tressel, R. P, Wysujack, K., Kotzamanis, Y. and Schulz C. (2011) Austausch von Fischmehl durch Rapsprotein konzentrat in Futtermitteln für Steinbutt (*Psetta maxima* L.). *Züchtungskunde*. 83:451–60.
- Talbot, C., Corneillie, S. and Korsøen, O. (1999). Pattern of feed intake in four species of fish under commercial farming conditions: implications for feeding management. *Aquaculture Research*, 30(7): 509–518.
- Thorpe, J. E. and Cho, C. Y. (1995). Minimizing waste through bioenergetically and behaviourally based feeding strategies. *Water Science and Technology*, 31(10): 29 – 40
- White, P. (2013). Environmental consequences of poor feed quality and feed management. *FAO Fisheries and Aquaculture Technical Paper*, 583: 553 – 564.
- Widjaja, W. P., Abdulmir, A. S., Saari, N. B., Abu Bakar, Bt. F. and Ishak, Z. B. (2009). Fatty acids profile of tropical bagridae catfish (*Mystus nemurus*) during storage. *Am. J. Food Technol.*, 4: 90-95.

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Relationship Between Water Volumes, Shapes, Glass Thicknesses And Water Holding Capacity Of 60 Litres Glass Aquaria

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Abstract

The relationship between water volumes, glass thickness, and water holding capacity 60 Litres (L) of glass aquaria were done using three shapes and thicknesses. Glass aquaria were designed and constructed using 3 mm, 4 mm and 5 mm thicknesses glass for Tower, Prism and Cuboid shapes in triplicate, which were tested for leakages. Water was introduced into each aquarium and monitored under room condition for 49 days. A significant difference occurred ($p < 0.05$) in the volume of water that can be retained by various shapes and thicknesses of glass aquaria. Aquaria of 3 mm thickness glass failed in retention of water of 60 L in all the shapes with a significant difference ($p < 0.05$) between shapes. 4 mm and 5 mm thicknesses failed in Prism and Tower shaped, during and shortly after filling without a significant difference ($p > 0.05$), while Cuboid shaped retained water, without significant difference ($p > 0.05$) occurred between 4 mm and 5 mm glass thicknesses in water retention capacity. Significant difference ($p < 0.05$) occurred between shapes and between glass thicknesses. Four-millimeter and 5 mm thicknesses are recommended for the construction of Cuboid shaped 60 L aquaria. Opportunity for choice of glass thicknesses based on customers' financial ability exist between 4 mm and 5 mm for Cuboid shaped glass aquaria. Minimizing loss of time, money, power and materials and increase healthy nation, job creation and wealth for the people are attainable based on this research outcome.

Key words: Glass aquaria, Glass thicknesses, Aquaria designs

Introduction

Ornamental fisheries are evolving aspect of fisheries called recreational fisheries in some instances. It is the study and production of special featured aquatic animal and plant (colour, shapes, movement, emission and activity), housing, marketing and managing them and their environment for aesthetic, recreational and healing purpose. Ornamental fish is a shellfish or finfish that attracts more value per unit weight than other aquatic animals of the same physical size as a result of its special feature(s) possessed for aesthetic purposes (beautification and endearment), recreation and health implication (natural therapy), it is regarded as the most valuable fish. It is generally smaller in size compared to table fishes except sport fishes (Olayimika, 2001). They are classified into salt and freshwater ornamental fishes. Ornamental fishes are mostly kept alive in an enclosure, those in aquarium are therefore referred to as aquarium fishes, while the sport fishes are mostly kept in the ponds, pools, lakes, streams, dams, reservoirs and recreational centres (Olayimika 2008, Olayimika, 2009, Olayimika and Lamai, 2010). Livengood and Chapman (2017) said "Ornamental fish is often used as a generic term to describe aquatic animals kept in aquarium hobby, including fishes, invertebrates such as corals, crustaceans (e.g., crabs, hermit crabs, shrimps), mollusks (snails, clams, scallops), and also live rock".

Ornamental fisheries are of great importance to human race, it is used for the following among others: Aesthetic purpose (beautification and endearment) for homes, offices and other places, recreational purpose (relaxation, picnic and tourism centres for people) and health purpose (prevent and control sicknesses caused by stress and brain fatigue such as Stroke, Hypertension). It also minimize vices in the society and family (where people will have opportunity to spend their time in viewing rather than being engaged in evil things), job and wealth creation for aquarium producers, fish breeders, marketers, foreign exchange for nations, research and learning at various levels.

Ornamental fish culture is fast becoming a major branch of aquaculture worldwide. Aquarium has tremendous economic opportunities and prospects, and is gaining recognitions very fast (i.e. ornamental fish and aquatic plant industry). The world ornamental fish trade is around US\$6 billion (Fossa, 2004). Ornamental fish export trade has been carried out in Nigeria for over 40 years, earning over \$1.5 million with about 100 identified species (Areola, 2004; Koroye, 2010). Ecotourism includes fisheries for other areas of human satisfaction apart from consumption (Fadipe, 2007; Yusuf and Ogundana, 2016), but the sector has long been neglected, probably due to lack of awareness of its large potentials (Chukwura, 2008). Yusuf and Ogundana (2016) said “Ornamental fishery production has not been fully taken into consideration due to some reasons which includes: lack of awareness about the possible use of ornamental fishes as an element of attraction, lack of technicalities in the area of culturing ornamental fishes, paucity of information on available source of ornamental fishes, and non interest of private individuals in breaking a truce in the area of making ornamental fishes an element of tourist attractions”. The hobby of keeping fish has been adopted by man in order to appreciate the grace and beauty of nature’s creatures (Odunaiya, 1986).

Ornamental fishes are kept at homes and offices in small compartments in most of the cases as an artificial home for viewing and recreational purposes, aquaria are mostly used for these. Thus, it is an enclosure that house aquatic organisms with at least a transparent side for viewing. The transparent side(s) is mostly made of glass with other useable materials like Acrylic and Perplex. There are various types of glass, and these include Annealed, Tempered or Toughened, Laminated, Heat strengthened and Reflective. Annealed glass is the cheapest, most common and most used of all the glasses in aquarium construction. Aquascaping (designing of aquarium) is exciting and is a major challenging part of the fish (ornamental) keeping hobby. The Ornamental fishes are usually kept in aquaria in homes for beautification and in public aquaria devoted primarily to the scientific study of plants and animals and they are usually made to stimulate the natural environment (Poluvin, 1996). Aquarium is a mini copy of the natural habitat of the fish, therefore care must be taken in designing, preparing and maintaining the aquarium's elements and ecosystem. Aquarium mostly serves as home in which ornamental fishes and other organisms are kept healthy, while sport fishes are kept in larger compartment in most cases.

Aquaria of various volumes and shapes are being designed to meet aesthetic demand of customers, to provide conducive environment for organisms that inhabit it and keeping water intact within it (Paranjayapet *al.*, 2014). Aquarium design entails conceiving and visualizing a concept, sketching it and developing the sketch, putting into consideration the organisms to be kept in it, the location it will be placed, the management that will be involved and interest of the consumer. The wall of the aquaria (size, shape and thickness) may affect its ability to function. Aquaria walls have to function as the air, water and weather barriers, that is designed to withstand the structural stresses imposed on it and its performance at room temperature, looking attractive to the customer and provide good environment (water) in which aquatic organisms survive. Glass is a material used for aquarium, it is brittle and with sudden failure structurally, which is dangerous. The theoretical strength of glass is very high tensionally and compressively, because of surface and edge flaws in the glass sheet this strength is not achieved in practice. Glass has a much lower coefficient of linear expansion (Table 1) than most metals (Warren, 2001).

Table 1: The glass physical characteristics

Physical Characteristics	Value
Density:	approx. 2.5 at 21°C
Coefficient of linear expansion:	$86 \times 10^{-7} \text{m/}^\circ\text{C}$
Softening Point:	730°C
Modulus of Elasticity:	69GPa (69 x 10 ⁹ Pa)
Poisson’s ratio:	Float Glass 0.22 to 0.23
Compressive Strength:	25mm Cube: 248MPa (248 x 10 ⁶ Pa)
Tensile Strength:	19.3 to 28.4MPa for sustained loading
Tensile Strength (toughened glass):	175MPa.

(Warren, 2001) People of diverse income, social status and concept demand for various shapes and sizes of aquaria to meet their need (aesthetic, healing). The quality and cost implication of procuring such have been a major challenge due to failure experienced based on strength of glass. Most aquaria builders make use of 4mm thick glass for construction of home and office aquaria without adequate information on the thickness capacity of such glass and the role that may be played by the shape and size of aquarium under consideration. Financial losses due to properties, fish and equipment damage as a result of cracks and breakages have been a major problem facing

aquarium producers and customers, especially in under-developed and developing nations. This is as a result of annealed glasses of mostly 3mm and 4mm commonly found in the market and mostly used by aquarist in construction of aquaria irrespective of shape and sizes. Ornamental fish is demanded everywhere in the world (Fossa, 2004, Ploeg, 2017). The suitability of various thicknesses of glass required for construction of various shapes of aquaria where the fish will inhabit to satisfy the customers will be derived in this research. However, the constraint of scientific application in design and construction has been a major challenge which this study also addressed.

Materials and Methods

Three replicates of each shape (i.e. Tower, Prism and Cuboid) were used under room condition with each replicate in separate room for each design. Sketch of the designs were drawn to scale using bisector, protractor, angles, ruler, pencil, paper and eraser. Glass sheets were procured and packed in cases (to prevent cracks and breakages), then transported to the project site, while hand gloves were worn for protection and glass sheets were cut into required sizes for construction using glass cutter from intersection points with the aid of long ruler for joining after measurement with measuring tape and accuracy confirmed using angle while the glass sheet is on the absorbent workshop table. Edges of the cut glass were dulled with dulling stone and hand towel used in cleaning the glass off particles. Sealant, Sealant Gun, Plump, Solvent. The sealant nozzle tip was cut slanting at 45° with an opening of 4-5 mm and the sealant's tip was cut, then the nozzle screwed to it and fixed into the sealant gun and triggered for 4-5 mm overflow. Assembling of each shape was done according to the specification. Cello-tape were cut to 10-15 cm and attached externally in pairs to all sides of the basement glass sheet, likewise a set of opposite sides to serve as a means of attachment for formwork formation while the glass sheets were located beside their potential position. Each of the side glass sheets were lifted-up and placed in its rightful position using the cello-tape to brace until all the sides were erected and positioned in its form. The aquaria were cured under room condition. The first curing took 45 - 60 minutes after construction, after which the aquarium was relocated from the workshop table for a pre-test, where water of 1-2 litres was used to test for leakages along the joints. A further cure that took a total of 24 hours was done before the aquaria were fully tested for leakages. Water was introduced into each aquarium gradually to determine the water holding capacity for different shapes and observed for forty nine days.

Results and Discussion

The experiment was conducted under average room temperature of 23.9 °C (22 – 27.5 °C) and average water temperature of 18.6 °C (16 – 21.5 °C). It shows that (Table 2) Three-millimeter (mm) glass thicknesses failed to retain 60 litres of water, they all failed during filling (Prism - 50.67±2.53 L, Tower and Cuboid 60.00±3.00 L) with a significant difference ($p < 0.05$) between the shapes. Four-millimeter (4 mm) failed to retain 60 L of water in Prism and Tower shaped (Prism - 54.33±2.72 and Tower 60.00±3.00) without a significant difference ($p > 0.05$), but retained water in cuboid shape with a significant difference ($p < 0.05$) from Prism and Tower shapes. Five-millimeter (5 mm) failed to retain 60 L of water in Prism and Tower shaped (Prism and Tower 60.00±3.00) without a significant difference ($p > 0.05$), but retained water in cuboid shape with a significant difference ($p < 0.05$) from Prism and Tower shapes, thus the thickness of glass affects the ability to retain water in glass aquaria. This shows that glasses of higher thicknesses are with better ability to retain water, this agrees with Aquarium Fish Tank (2015) that a thin glass required multiple bracing that makes it unattractive. In order to achieve a reasonable seeing area, there is need to consider thickness and material's type for the work. Failure occurred in 3 mm, 4 mm and 5 mm glass thicknesses in Prism shaped aquaria during and shortly after filling, with 3 mm significant different ($p < 0.05$) from 4 mm and 5 mm glass thicknesses. Failure occurred in 3 mm, 4 mm and 5 mm glass thicknesses in Tower shaped aquaria (60.00±3.00) during and shortly after filling without significant difference ($p > 0.05$) between 3 mm, 4 mm and 5 mm glass thicknesses. Failure occurred in 3 mm Cuboid shaped aquaria (60.00±3.00) during and shortly after filling, with 3 mm significant different ($p < 0.05$) from 4 mm and 5 mm glass thicknesses without failures. Significant difference occurred between Prism, Tower and Cuboid shaped aquaria ($p < 0.05$). The Shape of the Aquaria affect its ability to retain water, shape with the highest water column (depth) and only three bond sides had less ability to retain water of equal volumes, thus confirmed Aquarium Fish Tank (2015) concept that the choice of the right glass is critical in such applications because, it is a brittle material and is weak in tension due to its non-crystalline molecular structure. Also, Warren (2001) corroborates that glass has a much lower coefficient of linear expansion than most metals. **Failures occurred because it has only ability to bend a little before failure, this is in consonance with** Morgan (2010) that glass is a totally brittle substance. It will bend a very small amount, but has no capacity like most metals to deform. It will bend to a point and then break.

Aquaria builders have opportunity to offer quality aquaria to customers based on their demand using 4 mm and 5 mm glass thicknesses for Cuboid shaped glass aquaria of 60 L capacity base on economy and ability to eliminate

loss of time, energy, money and materials. Opportunity for choice of glass thicknesses based on customers' financial ability and aesthetic demand exist between 4 mm and 5 mm for Cuboid shaped glass aquaria for healthy, job and wealth creation for the people are attainable based on this research outcome.

Table 2: Relationship between water volumes, glass thicknesses, shapes and water holding capacity of 60 litres glass aquaria

Thicknesses → Shapes ↓	3 mm	4 mm	5 mm
Prism	50.67±2.53 ^a	54.33±2.72 ^b	60.00±3.00 ^b
Tower	60.00±3.00 ^b	60.00±3.00 ^b	60.00±3.00 ^b
Cuboid	60.00±3.00 ^b	No failure ^c	No failure ^c

P < 0.05

Volumes in Litres

Conclusion and Recommendation

Aquaria of Sixty (60) litres water holding capacity of Cuboid shapes can be design and constructed using 4 mm and 5 mm glass thicknesses, while 3 mm cannot be used for Prism, Tower and Cuboid shaped of the same capacity. As well, 4 mm and 5 mm cannot be used for Prism and Tower shaped of the same capacity. Further researches should be carried out on other glass thicknesses, shapes and volumes.

References

- Areola, F. O. (2004). Export potential of ornamental live fish in Nigeria. 19th Annual Fisheries Society Conference Proceedings, Calabar p.589
- Aquarium Fish Tank (2015). Retrieved from Build aquarium: <http://www.info.com>
- Chukwura, D. I. (2008). Ornamental fish industry, scope and project for future development in Nigeria, Newsletter of the Federal College of Fisheries and Marine Technology, Victoria Island, Lagos Pp2-12
- Fadipe, A. S. (2007). Basic principles and practice of tourism media, ACE, Lagos
- Fossa, S.A. (2004). Man-made fish: Domesticated fishes and their place in aquatic trade and hobby. *Ornamental Fish International Journal*, 44, 1-23
- Koroye, E. (2010). Export ornamental fish is big business, Magazine of African Aquaculture and Fisheries Digest 3 (8) 11
- Livengood, E. J. and Chapman, F. A. (2017). The ornamental fish trade: An introduction with perspectives for responsible aquarium fish ownership. UF/FAS Extension, University of Florida Retrieved from <http://edis.ifas.uft.edu>. October, 2017
- Morgan, T. (2010). *Aspect of Structural Glass*. Institute of Structural Engineers, SE Counties ranch 1-81
- Odunaiya, O. (1986). Investment Opportunity in Aquarium Technology-Export Marketing of Tropical Aquarium Fishes *Proceedings of the 5th Annual Conference of Fisheries Society of Nigeria* held at Ilorin, 261-269
- Olayimika, S.O (2001). Appraisal on the survival of the *Poecilia reticulata* (Guppy) as an ornamental fish in the Northern Nigeria (A case study of Minna, Niger State). A Master's degree thesis submitted to Postgraduate School, Federal University of Technology, Minna, Niger State, Nigeria.
- Olayimika, S.O (2008). Appraisal on the survival of the *Xiphophorus maculatus* (Platy) as an ornamental fish in the Northern Nigeria (A case study of Minna, Niger State). *Proceedings of Annual Conference of International Research and Development Institute, Research and Development Network* held June 24-27, 2008 at Institute for Development Research Hall, Ahmadu Bello University, Zaria, Nigeria 3:8; 121
- Olayimika, S. O. (2009). Effect of sex combination ratio on breeding of *Poecilia reticulata* (Guppy) for ornamental purpose. *Proceeding of Annual Conference of International Research and Development Institute* held at University of Porthacourt, September 2-3, 2009, 5: 5; 48-51
- Olayimika, S. O. and Lamai, S. L. (2010). Effect of parental sex and breed on phenotypical expression (colouration) in progeny of *Peocilia reticulata* (Guppy) for Ornamental Purpose. *Journal of Applied Agricultural Research* 2:1; 127-132
- Paranjayap, P., Martyn, P., Maluniu, O., Lettyb, B. (2014). [How to make an aquarium](http://www.glassfiles.com), Retrieved from <http://www.glassfiles.com>.
- Ploeg, A. (2017). The Indian ornamental fish industry. *Ornamental Fish International*. Retrieved from <http://www.ofish.org>.
- Poluvin, N. V. C. (1996). Reef fisheries. Chapman and Hall, London 7-47 adapted from Onuoha, P. C. (2008). A Preliminary Survey of Marine Ornamental Fishes in the Catches of Fishing Trawlers Operating Within the

- Nigerian Continental Shelf. *International Journal of Emerging Technology and Advance Engineering*. 4 (9)2250-2459, September 2014) p.1 Retrieved from www.ijetae.com
- Warren, (2001) adapted from NGS Group (2013). *Glass Selection*, Technical Bulletin ATS-122, 2013-01-14, Pilkington North America, Incorporation. 1 – 5 Retrieved from <http://www.pilington.com>.
- Yusuf, O. I. S and Ogundana, F. O. (2016). Ornamental Fish Tourism and Economic Development, *Journal of Ornamental and Recreational Industry* 14 (1) 1-5. Retrieved from www.transcampus.org/journal; [www.ajol.info/journal,jorind](http://www.ajol.info/journal/jorind)

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Effects of Aquaponics on Growth Performance of African Catfish (*Clariasgariepinus*)**Vincent-Akpu Ijeoma Favour, Akwijoro Elijah Rona**

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Abstract

This study was carried out from March 2021 to September 2021 to evaluate the impact of aquaponic system on growth performance of African Catfish (*Clariasgariepinus*). Twelve tanks consisting of four treatment tanks in triplicates were set up, Two economically important plants: Fluted Pumpkin (*Telfairiaoccidentalis*) and Cucumber (*Cucumissativus*) were planted in aquaponics tank T1 and T2 respectively with no water replacement; and two treatment tanks negative control (NC) and positive control (PC) without aquaponics plants, where water was replaced every three and seven days respectively. Sixty fingerlings were cultured in these tank for four weeks. Growth performance indices were measured weekly and analysed using ANOVA and LSD Post-Hoc. Specific growth rate, weight, standard, and total lengths of fish in aquaponics system tanks T1 and T2 were higher and significantly different ($P<0.05$) from those of fish in the negative and positive treatment control tanks (NC and PC). With aquaponics system, fish farmers can cultivate both fishes and plants sustainably.

Key Words: Aquaponics, Fish growth, Grow bed, *Clariasgariepinus*

Introduction

In developing nations such as Nigeria with increase in population, water scarcity especially in the northern regions, and high cost of food; aquaponics technology promises a sustainable approach to fish and plant cultivation. According to FAO (2014), aquaponics technology is an integration of plant cultivation into aquaculture in a recirculating ecosystem that utilizes natural nitrifying bacteria to convert fish wastes into plant nutrients. The plants are grown in a bio-filter to collect nutrients from the water, therefore purifying the water for the fish (Petkova and Krusteva, 2021). Aquaponics system consists of two tanks which are the fish tank and the plant grow bed (Karimanzira and Rauschenbach, 2021). The fish tank is the larger tank where the fishes are cultured; a water pump (usually submersible) pumps water from the fish tank into the plant grow bed where plants are cultivated (Nisha et al., 2018).

The principle behind aquaponics is simple: to raise fishes and plants with the same water. The fish waste water serve as fertilizer which the plants take as nutrients thereby purifying the water for the fish, so that farmers do not have to dispose of water regularly (Kyaw and Keong, 2017). According to the World Bank (2020) the cultivation of various plants by traditional agricultural methods will need more water as our population increases annually. Plants in one acre of land can consume over 200kg of fertilizer per cultivation cycle (Kundu, 2016). In aquaponics system, the fish wastewater is rich in ammonia, phosphorus, and other nutrients (Bosma, 2011) which are broken down or converted by microbes to be absorbed by the plants (Schmautzet al., 2017).

Love et al. (2014) carried a survey of eight hundred and nine aquaponics farmers and researchers across the world and found out that most persons practice aquaponics due to lack of space and the ability to control the nutrients their plants are fertilized with. Khandaker (2020) found out that most aquaponics farmers construct their aquaponics systems in greenhouses and considered the amount of carbon dioxide (CO₂) available in the greenhouse .

Thus, this study will determine the effects of aquaponics system on growth of African catfish (*Clariasgariepinus*) and to compare traditional aquaculture where water is regularly replaced with that of aquaponics

Materials and Methods**Collection of Materials for Aquaponics System**

Twelve 60-liter tanks for fish tanks, six 40-liter tanks for grow beds, gravels and bell siphons were purchased in a plumbing shop in Port Harcourt. Six1000 litres per hour submersible water pumps model EGP-1000L were imported

from China which worked simultaneously by pumping water from the fish tank into the grow bed for 3 minutes every 1 hour 30 minutes.

Preparation of Aquaponics Grow Bed

Grow beds were constructed using six 40-liter tanks, with gravels and a bell siphon. The gravels were soaked in water for 2 weeks, washed with a brush, sun-dried, and then soaked in water for one week to prevent the alteration of the water pH. Gravels were arranged into the system to enable proper water drainage and aeration for plant roots and prevent sunlight from reaching the root of plants. The grow bed tanks had 8 liters of water each because of the gravels present in them.

Test Organisms

Sixty fish fingerlings with an average weight of $33.9 \pm 9.04\text{g}$ and length of $13.38 \pm 2.96\text{cm}$ were collected from the African Regional Aquaculture Center (ARAC), Aluu, Port Harcourt. All fishes were acclimatized for 7 days before they were transferred into the treatment tanks (five fish each).

Fluted Pumpkin (*Telfairia occidentalis*) and Cucumber (*Cucumis sativus*) seeds were purchased from Choba Community Market and nursed for 14 days before introducing into the set ups. Before transplanting, the root of each individual crop was carefully rinsed with water to remove every soil.

Treatment and Control

Twelve tanks consisting of four treatment tanks in triplicates were set up. With the aid of submersible water pumps, water was pumped from the fish tanks into the aquaponics systems with replicates labelled T1 (fluted pumpkin) and T2 (Cucumber) and back into the fish tanks once every one hour thirty minutes. No water was drained or removed from these treatment tanks T1 and T2, but 2 litres of water were added to them to make up for water loss by transpiration.

Two treatment tanks in triplicates without aquaponics system where water was changed completely for every three days were positive control (PC) treatment tanks while negative control (NC) treatment tanks had water change every 7 days. All tanks had a volume of 50 litres of water each. Fish were given 5% of their body weight of feed daily (three times daily) using Blue Crown feed.

The physical and behavioral changes in the set up were observed and recorded. The weight, standard length, and total length of fish were measured weekly using a digital micro scale with model number GE779HA1BCNAFAMZ for weight and meter rule for length.

Specific growth rate were calculated and compared using the formula

$$SGR = \frac{\log_e(W_2) - \log_e(W_1)}{T_2 - T_1} \times 100$$

Where SGR is Specific Growth Rate, W_2 is final weight, W_1 is initial weight, T_1 is the initial day and T_2 is the final day.

Statistical Analysis

Results obtained were wrangled and pre-processed with Microsoft Excel 2013 before Exploratory Data Analysis (EDA) was used to carryout ANOVA, Least Significant Difference, and Pearson Correlation in the R Studio IDE. Every charts and graph were created using the R Language.

Results

Weight

Table 1 shows fish weight, standard length, total length, and specific growth rate in each tank across the various weeks. After week1, fish in the cucumber aquaponics tank (T2) weighed the most with an average of $67.8 \pm 12.74\text{g}$. The tank that recorded the lowest average weight of fish in week one was the negative control tank (NC) with $43.8 \pm 14.06\text{g}$. Fishes in every tank kept growing and in the final week (week 4), fishes in the fluted pumpkin aquaponics tank (T1) weighed $125.7 \pm 20.34\text{g}$. In the cucumber aquaponics tank (T2), the average weight of fishes in the final week was $129.33 \pm 20.64\text{g}$. In that same week, average weights of $94.33 \pm 23.4\text{g}$ (for negative control tank) and $106.47 \pm 19.5\text{g}$ (for positive control tank) were recorded. There was no significant difference ($P < 0.05$) in the weight

of the fish between the treatment tanks and the control tanks. Figure1 show the weight progression of fish in each tank across the various weeks.

Standard Length

Fish in T1 had an average standard length of 24.4 cm in the first week and in the fourth week of the experiment, the standard length of fish in T1 became 39.2 cm (Table 1). Fish in T2 had an average standard length of 25.1 cm in the first week, and 40.2 cm in the final week. As for the fish in the control tanks, the average standard lengths of fish in the first week were 19.3 cm (NC) and 19.7 cm (PC). In the final week, the average standard length of PC and NC fish become 31.6 cm (NC) and 34.6 cm (PC) respectively. There was significant difference ($P < 0.05$) in the standard length of fish across the various tanks during the course of this experiment. Figure 2 shows the average standard length of fish in each tanks across the various weeks.

Total Length

In the first week of the experiment, the average total length of fish in the various tanks were 26.1 cm (T1), 27.6 cm (T2), 20.8 cm (NC), and 21.5 cm (PC). The final average length of fish in the various tanks in week four were 41.8 cm (T1), 42.7 cm (T2), 33.1 cm (NC), and 36.6 cm (PC). There was significant difference ($P < 0.05$) when the total length of fish in each tanks across the various weeks were compared using ANOVA. Figure 3 shows the trend of the total length in each tank across the various weeks.

Specific Growth Rate (SGR) of Fish

The negative control (NC) tank had the lowest SGR of 1.602 g/day throughout the experiment. The tank with the highest SGR was the cucumber aquaponics tank (T2) with 2.092 g/day. Other tanks had SGR of 2.048 g/day (T1), and 1.79 g/day (PC).

Table 1: Initial and final weight, standard length, total length, and specific growth rate of fishes aquaponics and non-aquaponics tanks in four weeks

Tank/Growth Parameter	Fluted Pumpkin (T1)	Cucumber (T2)	Negative Control (NC)	Positive Control (PC)
Initial Weight (g)	64.8 ± 9.98 ^{ab}	67.8 ± 12.74 ^a	43.8 ± 14.06 ^c	45.4 ± 8.44 ^{bc}
Final Weight (g)	125.7 ± 20.34 ^a	129.33 ± 20.64 ^a	94.33 ± 23.4 ^b	106.47 ± 19.5 ^b
Initial Standard Length (cm)	24.4 ± 2.54 ^{ab}	25.1 ± 2.46 ^a	19.3 ± 1.68 ^c	19.7 ± 2.04 ^{bc}
Final Standard Length (cm)	39.3 ± 4.67 ^a	40.2 ± 4.58 ^a	31.6 ± 3.54 ^b	34.6 ± 4.01 ^b
Initial Total Length (cm)	26.9 ± 2.46 ^{ab}	27.6 ± 2.45 ^a	20.8 ± 1.75 ^c	21.5 ± 2.12 ^{bc}
Final Total Length (cm)	41.8 ± 4.58 ^a	42.7 ± 4.67 ^a	33.1 ± 3.89 ^b	36.6 ± 3.91 ^b
Specific Growth Rate	2.048 ± 0.38 ^a	2.092 ± 0.53 ^a	1.602 ± 0.34 ^b	1.79 ± 0.26 ^c

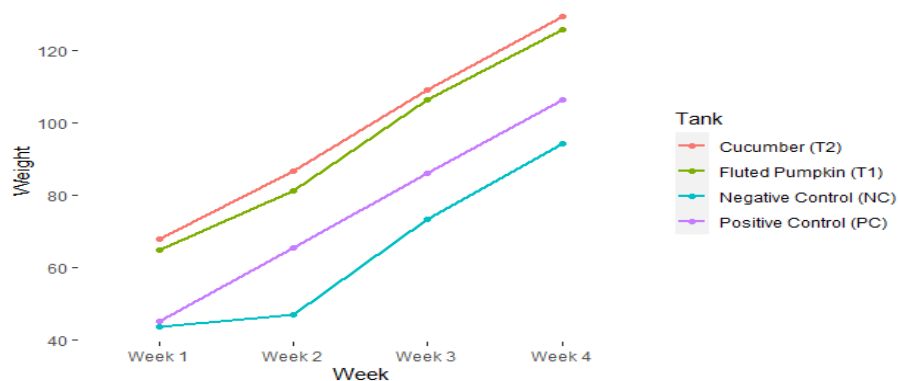


Figure 1: Weight of fish across various aquaponics and non-aquaponics tanks in four weeks

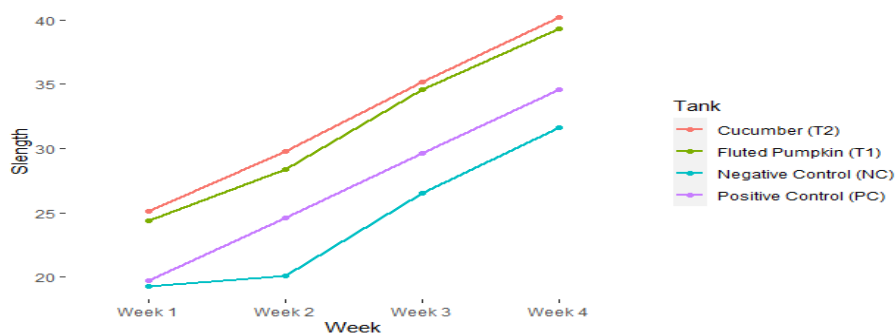


Figure 2: Standard Length of fish across the various aquaponics and non-aquaponics tanks in four weeks

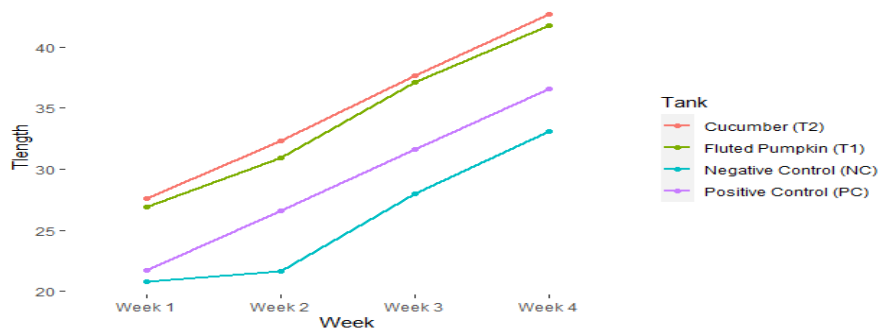


Figure 3: Total Length of fish across various aquaponics and non-aquaponics tanks in four weeks

Discussion

There was significant difference ($P < 0.05$) in the weight, standard, and total lengths of fish grown in the aquaponics tanks when compared to fishes grown in tanks with water change. This is in line with the findings of Setiadi *et al.* (2018), and Widyastuti *et al.* (2019) where fishes grown in aquaponics systems had specific difference in their growth when compared with fish grown in traditional aquaculture.

Denderen *et al.* (2020) noted that the factors that affect the growth of fish are the fish species, stocking density, water quality, quality of feed, and feeding rate. Oladimeji, *et al.* 2020 recorded a higher specific growth rate in fish in aquaponics when compared with fish grown in both static and recirculating aquaculture systems. They used fluted pumpkin plants on African catfish (*Clarias gariepinus*) in an aquaponics experiment and recorded greener and broader leaves in the aquaponics plants. They also noted that water quality has an effect on the growth of fish, as poor water quality made the fish to stop feeding and expend more energy and nutrients to repair tissue instead of growing. In the experiment, fish in the negative control with one water change per week had the least specific growth rate of 1.602 as the water quality was relatively poor that they refused to eat and showed signs of suffocation. Since every fish was cultured with the same stocking density, fed with the same quality and quantity of feed daily, the only factor that could cause the variation of their specific growth rate is the water quality. Moreover, fish in aquaponics tanks (T1, and T2) attracted several insects to the fish tank and the fish ate these insects. Since water is not drained off in aquaponics but only recirculates, aquaponics is a sustainable solution to mitigate and prevent the build-up of organic matter in streams, rivers, and aquifers as spent fish water is not disposed (Mohanty *et al.*, 2018). Oladimeji *et al.* (2020) noted that plants grown traditionally are exposed to soil pathogens, but those cultivated in aquaponics are free from soil pathogens, have steady supply of nutrients, so they grow faster and healthier than plants grown traditionally. Vitale (2021) noted that aquaponics plants attract insects and other invertebrates that can serve as food to aquaponics fishes, which was evident in the aquaponics tanks (T1 and T2) as several insects were seen on the tanks.

The water in aquaponics can be used as free readily-available organic fertilizer for plants. Nitrates released by the fish does not burn plants (Liu *et al.*, 2017), so as much water from aquaponics as needed can be used as fertilizer for

plants. Aquaponics technology has a lot of advantages over traditional agriculture and aquaculture, so more farmers and researchers should embrace aquaponics (FAO, 2014).

Conclusion

We need to embrace sustainability in every of our activities. Whether in agriculture, resource extraction, or in business, we should consider the negative effects of our activities on the environment and mitigate them. Introducing aquaponics into traditional aquaculture will increase fish growth, reduce feed cost, minimize water use and effluent discharge, and thus reduce our negative footprint on the Earth. Traditional aquaculture poses a lot of threat to the environment, but with aquaponics, fish farmers can finally cultivate both fishes and plants sustainably.

References

- Bosma, R., & C.J.Verdegem, M. (2011). Sustainable aquaculture in ponds: principles, practices and limits. *Livestock Science*, 139(1):58-68.
- Denderen, D. V., Gislason, H., Heuvel, J. V., & Andersen, K. H. (2020). Global analysis of fish growth rates shows weaker responses to temperature than metabolic predictions. *Global Ecology and Biogeography*, 29(12):2203-2213.
- FAO. (2014). *Small-scale aquaponic food production*. FAO Fisheries And Aquaculture Technical Paper 589, Rome.
- Karimanzira, D., & Rauschenbach, T. (2021). An intelligent management system for aquaponics. *Automatisierungstechnik*, 69(4):345-350.
- Khandaker, M. (2020). Vertical Aquaponics and Investigation of Aquaponics on Asian Vegetables. Vertical Aquaponics and Asian vegetables. 2020 Aquaponics Association Virtual Aqua-Conference
- Kundu, D. K. (2016, july). *How to calculate the amount of a fertilizer(fine powders) need for the nutrition of one acre*. Retrieved from research gate: <https://www.researchgate.net/post/how-to-calculate-the-amount-of-a-fertilizerfine-powders-need-for-the-nutrition-of-one-acre>
- Kyaw, T. Y., & Keong, A. (2017). Smart aquaponics system for urban farming. *Energy Precodia*, 143: 342–347.
- Liu, G., Du, Q., & Li, J. (2017). Interactive effects of nitrate-ammonium ratios and temperatures on growth, photosynthesis, and nitrogen metabolism of tomato seedlings. *Scientia horticulturae*, 214:41-50.
- Love, D. C., Fry, J. P., Genello, L., Hill, E. S., Frederick, J. A., Li, X., & Semmens, K. (2014). An international survey of aquaponics practitioners. *Plos one* 9(7)1-8e102662. doi:10.1371/journal.pone.0102662
- Mohanty, R. K., Ambast, S., Panigrahi, P., & Mandal, K. (2018). Water quality suitability and water use indices: useful management tools in coastal aquaculture of *litopenaeus vannamei*. *Aquaculture*, 485:210-219.
- Nisha, S., Acharyaa, S., Kumar, K., Singh, N., & Chaurasia, O. (2018). Hydroponics as an Advanced Technique for Vegetable Production: An Overview. *Journal of Soil and Water Conservation*, 17(4):364-371
- Oladimeji, S. A., Okomoda, V. T., Olufeagba, S. O., Solomon, S. G., Abol-Munafi, A. B., Alabi, K. I., & Ikhwanudin, M. (2020). Aquaponics production of catfish and pumpkin: comparison with conventional production system. *Food Science And Nutrition*.8(5): 2307–2315.
- Petkova, V., & Krusteva, K. (2021). Comparative analysis of aquaponics and hydroponic systems. *Annual Of Natural Sciences Department*, 5:31-43.
- Setiadi, E., Widyastuti, Y. R., & Prihadi, T. H. (2018). Water quality, survival, and growth of red tilapia, *Oreochromis niloticus* cultured in aquaponics system. *E3s Web of conference*47:1-8.
- Schmautz, Z., Graber, A., Jaenicke, S., Goesmann, A., Junge, R., & Smits, T. H. (2017). Microbial diversity in different compartments of an aquaponics system. *Archives of microbiology*, 199(4):613–620.
- Vitale, R. (2021). Urban horticultural and aquaponics for sustainability development in circular economy. Retrieved from <https://www.authorea.com>.1-8
- World Bank. (2020, may). *Water in Agriculture*. Retrieved from world bank: <https://www.worldbank.org/en/topic/water-in-agriculture>
- Widyastuti, Y. R., Setiadi, E., Taufik, I., & Setijaningsih, L. (2019). Water quality dynamic, production and profitability of catfish, *Clarias sp.* cultured at different design construction of aquaponic. *IOP conference Series: Earth And Environmental Science*. 236(1):012-028.

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Effect of Water Replacement on Ph and Growth of *Clarias gariepinus* fry**Amachree, D*, Ikuromo, E. J and Felix, B**Department of Fisheries and Aquatic Environment, Rivers State University, Nkpolu-Oroworukwo, P. M. B. 5080, Port Harcourt, Rivers State, Nigeria. *dokuboba.amachree@ust.edu.ng**Abstract**

The pH of water is a vital water quality parameter that affects the growth and survival of fish. This study aimed to investigate the effect of water replacement (%; 100, 50, 25 and 10) on the pH and growth of *Clarias gariepinus* fry for 14 days. Water quality parameters (temperature °C; pH; dissolved oxygen, mg/l) were monitored weekly immediately before water replacement and immediately after water replacement. Weekly growth performance of *C. gariepinus* fry were measured. The result showed that for all water parameter measured, there were statistically significant difference for the immediately before water replacement compared to the immediately after water replacement (student t-test, $p < 0.05$). At the end of the experiment, pH was significantly increased (pH 6.5) in the 10% water replacement compared to other treatments (ANOVA, $p < 0.05$). The values (mean $\pm$ SD) were 5.0 ± 0.1 (4.6 ± 0.1); 5.6 ± 0.2 (4.8 ± 0.1); 5.8 ± 0.1 (5.8 ± 0.4) and 6.5 ± 0.0 (5.9 ± 0.0) for 100, 50, 25 and 10% water replacement for the immediately before water replacement and immediately after water replacement (bracket) respectively. Also, there were significant differences in growth parameters measured. The 50% water replacement showed significant length increase compared to the other treatments (ANOVA, $p < 0.05$). For weight gain and specific growth rate, the 50% and 100% were significantly increased compared to the other treatments. At the end of the experiment, the highest percentage survival rate ($74 \pm 4.62\%$) was seen in the 50% water replacement followed by $63 \pm 3.00\%$ in the 100% water replacement. The least % survival rates (54 ± 4.06 and $52 \pm 4.04\%$) were seen in the 25 and 10% water replacement respectively. In conclusion, although the ideal pH (6.5) was seen in the 10% water replacement, survival and growth performance were better in the 50% and 100% water replacement.

Keywords: Survival, Early life stage, water exchange, acidic water, pH**Introduction**

The hydrogen ion concentration (pH) is one of the main factor affecting water quality for fish production (Reynalte-Tatajeet *et al.*, 2015). Kleerekoper, (1990) indicated that the pH is important because the proportion of H^+ and OH^- ions in solution extensively regulates several physiological processes that are critical to the organisms. Most aquatic organisms show a remarkable preference for a particular pH. Extreme pH can negatively affects fish survival and growth (Zweig *et al.*, 1999; Uzoka *et al.*, 2015). Sensitivity to extreme pH conditions varies according to fish species and age, with fish showing lower tolerance at the embryonic and larval stages. Marimuthu *et al.* (2019) recommended a water pH level of 6.7-7.5 as ideal for hatching and survival of *C. gariepinus* larvae. As pH levels deviates from this range (up or down) it reduces hatching and survival rates (Zweig *et al.*, 1999; Marimuthu *et al.*, 2019), as well as affects development and physiological conditions of fish (Zelennikov, 1997; Keinanemet *et al.*, 2003).

Also, most water replacement strategy has been used to improve general condition of the quality of water. Reports on water replacement to improve pH is scarce. Water replacement after hatching to improve pH of water has been practiced by most farmers (including the present experimental area) and has shown great success in the production of *C. gariepinus* fry (unpublished). However, the actual percentage that improves pH for optimum survival and growth has not been established. Reports have shown the efficacy of organic materials (e.g., oyster shell, banana or plantain peels) for buffering pH (Davies and Jaja 2014; Davies and Ansa 2014). However, these methods will incur extra cost for the farmer and may require technical know-how. African catfish is the most popular species of fish among the fish farmers and consumers in Nigeria because it commands a good commercial value and as a result provides employment for many. This study intends to provide a less technical, natural and inexpensive approach by using the same water obtained from the farm but different percent of replacement to determine the ideal percentage that will improve the water pH for optimal survival and growth of *C. gariepinus* fry.

2.0. Materials And Method

2.1 Experimental Area and Experimental Design

The experiment was carried out in the Aquaculture Centre, Department of Fisheries and Aquatic Environment, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt. The complete randomized design was used for the experiment. A total of four treatments (% water replacement; 100, 50, 25 and 10) were established (Table 1). For the 100% replacement, 100% of experimental water was replaced daily with fresh farm water; for the 50% replacement, 12.5 litres of the experimental water was replaced daily with fresh farm water; whereas for the 25% replacement treatment, 6.25 litres of the experimental water was replaced daily with fresh farm water; and for the 10% replacement, 2.5 litres of the experimental water was replaced daily with fresh farm water.

Table 1: An overview of the experimental design

% Water replacement	Litres of water in aquarium	Litres to be replaced
100	25	25
50	25	12.5
25	25	6.25
10	25	2.5

2.2 Determination of Water Quality Parameters

Water in the experimental aquaria were replaced daily and water quality parameters were measured weekly immediately before water replacement and immediately after water replacement. Water quality parameters including temperature (°C), pH, dissolved oxygen concentration (mg/l) were measured *in situ* with a hand-held probe (DO 700, EXTECH instruments, Aflir company). While water samples for alkalinity and calcium were collected in sample bottles and taken to the Institute of Pollution Studies Laboratory, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt for analysis.

2.3. Stocking Density, Length and Weight Measurement

One hundred of 5 days old fry were randomly selected and allocated to 12 plastic aquaria (i.e., triplicate design of each treatment) containing 25 L of pre-condition (allowed to seat for a day) water each. The initial total length (cm) and weight (g) of the fry were measured according to Ukweet *al.* (2017) with slight modifications. Briefly, the total length (cm) of 25 fry were measured using a transparent millimeter calibrated ruler and a magnifying hand lens. From the mean length, the length (0.14cm) of each fry was calculated. For the whole body wet, a wet filter paper was placed in a digital scale (diamond series A04) and tared. Thereafter, twenty five fry were randomly collected and placed on the pre-weighed filter paper and recorded. This was repeated three times, and the average of the results of the three sets was taken and the weight (0.012g) of each fry was calculated. For days 7 and 14, ten fry were taken from each tanks and the whole wet weight (g) was taken as a group of 10 fry, individual total length (cm) was taken also. Fry were fed at 10% body weight (Epbah and Amachree, 2019) with Ziglar (0.3mm) commercial feed throughout the experimental period. Feeding was done twice daily to enhance optimum growth (Davies *et al.*, 2006). Length and weight measurement of fingerlings was carried out weekly throughout the period of the experiment.

2.4. Statistical Analysis of Data

Statistical analysis was conducted using the Minitab 16 for Windows. Data was pooled by treatment and presented as mean $\pm$ standard deviation. Data were analysed for treatment and time effect by two-way analysis of variance (ANOVA). Where treatment $\times$ time showed significant interaction, one-way ANOVA was used to test for treatment effects within a time or time effect within a treatment. The Turkey post-hoc test was used at 95% confidence level to provide specific information on which means are significantly different from each other. Student t-test ($p < 0.05$) was used to compare two means.

3.0. Result and Discussion

3.1 Water Quality Characteristics

The results of the water quality characteristics measured immediately before water replacement (first row) and immediately after water replacement (second row data in parenthesis for each parameter) are presented on Table 2.

There were time- and treatment-dependent differences in pH and DO but not temperature. For example, at the end of the experiment (day 14), the pH was significantly increased (pH 6.5) in the 10% water replacement compared to other treatments (ANOVA, $p < 0.05$). The values (mean $\pm$ SD) were 5.0 ± 0.1 (4.6 ± 0.1); 5.6 ± 0.2 (4.8 ± 0.1); 5.8 ± 0.1 (5.0 ± 0.4) and 6.5 ± 0.0 (5.9 ± 0.0) for 100, 50, 25 and 10% water replacement for the immediately before water replacement and immediately after water replacement (bracket) respectively. Also, the result showed that for all water parameters measured, there were statistically significant difference for the immediately before water replacement compared to the immediately after water replacement (student *t*-test, $p < 0.05$, Table 2). The difference between the immediately after- and immediately before water replacement was a result of freshwater introduced into the experimental tanks. Also, as indicated in the results (Table 2), values in the immediately after water change (bracket) for all parameters measures increased as the percentage of water been replaced decreases. In practice in our farm, it has been observed that when water with low pH (~ 4.5) is allowed to sit for up to 2 days the pH can raise up to 6.5 (Felix, 2021: *personal communication*). The reason for this is unclear as temperature (one factor that affects pH) is similar in all treatments per time. Water replacement (also called Exchange) is a common practice in aquaculture, it is used as an economically efficient method to maintain good water quality. For shrimp culture 25%/day water replacement was recommended as ideal to improve water quality and production (Hopkins *et al.*, 1993). In the present study, the 10%/day water replacement showed the highest pH (6.5) which is within the range (6-9) recommended for aquaculture (Boyd, 2017).

Table 2: Water quality measurements of experimental water during 14 days of water replacement

Experimental Period (Days)	Parameters	Treatments (%)			
		100	50	25	10
0	Temperature ($^{\circ}$ C)	24.5 $\pm$ 0.4 ^a	24.4 $\pm$ 0.5 ^a	24.2 $\pm$ 0.0 ^a	24.2 $\pm$ 0.0 ^a
		(25.8 $\pm$ 0.0) ^{a*}	(25.2 $\pm$ 0.0) ^{a*}	(25.0 $\pm$ 0.0) ^{a*}	(25.5 $\pm$ 0.5) ^{a*}
	pH	5.6 $\pm$ 0.0 ^a	5.6 $\pm$ 0.2 ^a	5.6 $\pm$ 0.0 ^a	5.6 $\pm$ 0.1 ^a
		(4.5 $\pm$ 0.2) ^{a*}	(5.1 $\pm$ 0.1) ^{b*}	(5.3 $\pm$ 0.5) ^{b*}	(5.7 $\pm$ 0.0) ^{b*}
	DO (mg/l)	3.6 $\pm$ 0.1 ^a	3.4 $\pm$ 0.3 ^a	3.6 $\pm$ 0.4 ^a	3.5 $\pm$ 0.3 ^a
		(3.6 $\pm$ 0.2) ^{a*}	(3.8 $\pm$ 0.3) ^{a*}	(3.6 $\pm$ 0.4) ^{a*}	(4.2 $\pm$ 0.4) ^{a*}
14	Temperature ($^{\circ}$ C)	23.4 $\pm$ 0.0 ^{aS+}	23.4 $\pm$ 0.0 ^{aS+}	23.4 $\pm$ 0.0 ^{aS+}	23.4 $\pm$ 0.0 ^{aS+}
		(25.6 $\pm$ 0.0) ^{a*}	(25.6 $\pm$ 0.0) ^{a*}	(24.9 $\pm$ 0.6) ^{ab*}	(24.6 $\pm$ 0.0) ^{b*}
	pH	5.0 $\pm$ 0.1 ^{a+}	5.6 $\pm$ 0.1 ^{bS+}	5.8 $\pm$ 0.1 ^c	6.5 $\pm$ 0.0 ^{d+}
		(4.6 $\pm$ 0.1) ^{a*}	(4.8 $\pm$ 0.1) ^{a*+}	(5.0 $\pm$ 0.4) ^{bS*+}	(5.9 $\pm$ 0.0) ^{b*+}
	DO (mg/l)	3.5 $\pm$ 0.1 ^a	3.5 $\pm$ 0.1 ^a	3.5 $\pm$ 0.2 ^a	3.5 $\pm$ 0.0 ^a
		(4.6 $\pm$ 0.0) ^{aS*}	(4.7 $\pm$ 0.0) ^{aS*+}	(5.1 $\pm$ 0.3) ^{bS*+}	(5.5 $\pm$ 0.0) ^{bS*+}

Data are mean $\pm$ SD for immediately before water replacement (first row for each parameter) and immediately after water replacement (second row data in parenthesis for each parameter). Different letter within a roll indicated significant treatment effect ($p < 0.05$). \$ indicates significant time effect within a treatment compared to the previous day ($p < 0.05$) compared to the previous time. + indicates significant time effect compared to day 0 (ANOVA, $p < 0.05$). * indicates significant effect between immediately before water replacement (first row for each parameter) and immediately after water replacement (second row for each parameter) (Student's *t*-test, $p < 0.05$).

3.2. Survival and Growth of *C. gariepinus* fry

The results of growth parameter showed that there were significant differences in growth parameters measured. The 50% water replacement showed significant length increase compared to the other treatments (ANOVA, $p < 0.05$, Figure 1). For weight gain and specific growth rate, the 50% and 100 % water replacement were significantly increased compared to the other treatments. At the end of the experiment, the highest percentage survival rate

(74±4.62%) was seen in the 50% water replacement followed by 63±3.00% in the 100% water replacement. The least % survival rates (54±4.06 and 52±4.04%) were seen in the 25 and 10% water replacement respectively. The high % survival rate and increased growth observed in the 100 and 50% water replacement treatment also had low pH (Table 2) compared to the other treatments, this might be because catfish (even at early life stages) are more resistant to pH stress than other fish species (Marimuthu *et al.*, 2019). According to Boyd (2017), the optimum pH for best growth is between 6 and 9, pH outside this range, fishes can be stressed resulting in less growth and greater susceptibility to disease which is not the case in the present study.

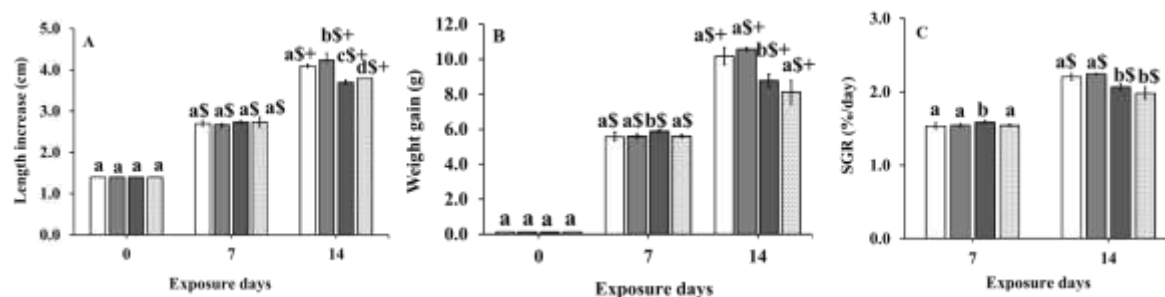


Fig 1. The growth measurements (A) Length increase (B) weight and (C) Specific growth rate of *C. Gariepinus* fry during 14 days replacement of 100% (white bar), 50% (grey bar), 25% (black bar) and 10% (pattern bar) water in the experimental tanks. Data are means ± SEM. Different letters within an experimental day indicates statistical significant difference (ANOVA, $p < 0.05$). \$ indicates significant time effect within a treatment ($p < 0.05$) compared to the previous time. + indicates significant time effect compared to day 0 (ANOVA, $p < 0.05$).

3.5. Conclusion

In conclusion, although the ideal pH (6.5) was seen in the 10% water replacement, survival and growth performance were better in the 100% and 50% water replacement.

References

- Boyd, C (2017). The inevitable pH fluctuations of aquaculture pond water. Responsible Seafood advocate. Accessed online: <https://www.globalseafood.org/advocate/the-inevitable-ph-fluctuations-of-aquaculture-pond-water/>. Last accessed date: 27th January 2022.
- Davies, O.A and Jaja, E (2013). Buffering assessment of pawpaw (*Carica papaya*) leaves and stem for fish production in Port Harcourt, Nigeria. *International Letters of Natural Sciences*, (4) 10-25.
- Davies, O. A and Ansa, E. J. (2014). Evaluation of buffering potency of oyster (*Crassostrea gasar*) shells for aquaculture in the in the Niger Delta, Nigeria. *Journal of Aquatic Sciences*, 29 (2B): 335-347.
- Epbah, H and Amachree, D (2019). Growth and survival of *Clarias gariepinus* (Burchell, 1822) fingerlings during single and combined commercial feed trials. *Tropical Freshwater Biology*, 28 (1): 77-87.
- Felix, B. (2021). Aquaculture Centre, Department of Fisheries and Aquatic Environment, Rivers State University, Nkpolu-Oroworukwo, Port Harcourt, (Personal communication).
- Hopkins, J. S., Hamilton II, R. D., Sandier, P. A., Browdy, C. L and Stokes, A. D (1993). Effect of water exchange rate on production, water quality, effluent characteristics and nitrogen budgets of intensive shrimp ponds. *Journal of World Aquaculture Society*, 24 (3): 304-320.
- Keinnnen, M., Tigerstedt, C. Kalax, P and Vuorinen, P. J (2003). Fertilization and embryonic development of whitefish (*Coregonus lavaretus*) in acidic low-ionic strength water with aluminum. *Ecotoxicology and Environmental Safety*, 55: 314-329.
- Kleerekoper, H. 1990. Introdução ao Estudo da Limnologia. Porto Alegre, Ed. da UFRGS.
- Marimuthu, K., Palaniandy, H and Muchlisin, Z. A (2019). Effect of different water pH on hatching and survival rates of Africa catfish, *Clarias gariepinus* (Pisces: Clariidae). *Aceh Journal of Animal Science*, 4 (2): 80-88.
- Reynalte-Tataje, D. A., Baldisserotto, B and Zaniboni-Filho, E. (2015). The effect of water pH on the incubation and larviculture of curimatá *Prochilodus lineatus* (Valenciennes, 1837) (Characiformes: Prochilodontidae). *Neotropical Ichthyology*, 13 (1): 179-186.
- Ukwe, I. O. K., Jamabo, N. A and Amachree, D (2017). Evaluation of growth performance of *Clarias gariepinus* larvae fed *Artemia* and Aqualis starter feeds. *Journal of Aquatic Sciences*, 32(1B): 159-169

- Uzoka, C. N., Anyanwu, J. C., Uche, C. C., Ibe, C. C and Uzoma, A. (2015). Effect of pH on the growth performance and survival rate of *Clarias gariepinus* fry. *International Journal of Research in Biosciences*. 4(3): 14-20.
- Zelennikov, O.V. (1997). The effect of acidification on oogenesis of rainbow trout during sex differentiation. *Journal of Fish Biology*, 50: 18-21.
- Zweig, R. D., Morton, J.D and Stewart, M. M.(1999). Source of water quality for aquaculture - A guide for assessment. The International Bank for Reconstruction and Development, the World Bank Washington, D.C, pp. 62.

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Effects of Testosterone Propionate on the Sex-Ratio Determination in *Clarias gariepinus* fry Reared in Concrete Water Tanks

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Abstract

Three hundred *Clarias gariepinus* fry were stocked in eighteen concrete watertanks. Stocking density was fifty fry per 2 by 2 metres square tank. Duration of experiment was one hundred and twenty-one (121) days. *Clarias gariepinus* fry were fed with Ecofloat feed at 5% of their body weight till the end of experiment. There were six treatments all triplicated for T₁₂₅, T₁₀₀, T₇₅, T₅₀, T₂₅, T₀. The mean initial weights were from 1.21 ± 0.30(g). The highest frequency of male fish recorded were 92.5%, 85% and 82% for T₅₀, T₇₅ and T₁₀₀. The lowest frequency was seen as 30% in T₁₂₅. T₀ showed 40% frequency of male fish from the study. The highest mean final weights was 7.25 ± 0.44(g) for *Clarias gariepinus*. Food conversion ratio (FCR) showed a non-significant difference (P>0.05) throughout the treatments. Performance Index (PI) value 4.00 ± 0.00 was seen in the T₁₀₀, T₇₅, T₅₀, T₂₅ tanks. Highest survival rate (SR%) of 98.5 ± 1.9 was also seen in the T₅₀ *Clarias gariepinus* fry tanks. Condition factor (CF) was however, significantly different (P<0.05) between treatments T₁₂₅ and T₁₀₀ and non-significantly different (P>0.05) between treatments T₇₅ and T₅₀; T₂₅ and T₀.

Keywords: *Clarias gariepinus*, concrete tank fry, sex-ratio, testosterone propionate

Introduction

Hormones are essential in fish production as it fosters understanding of the dynamics of sex differentiation. Androgens and estrogens must therefore be handled with care, while fish is given adequate management to ensure a successful fish production (Robert *et al.*, 2019c). Sex-reversal of fish to all-male involves administering a male hormone to newly hatched fry, only seven days old as five-day old hormonal treatment resulted in unsuccessful sex-reversal (Alam and Uddin, 1998). This is carried out early so the undifferentiated gonadal tissue of the naturally generic female of the fish to be used will in turn develop testicular tissue enabling it to function as a male (Megbowon *et al.*, 2009; Megbowon and Mojekwu, 2014; Robert *et al.*, 2019c). An encouraging supply of fry of a particular sex was the aim for this study. Again, the need to determine optimal dose for this research was another specific objective. Dietary administration and supply of feed mixed with the male androgen has proven to be most successful from previous reports (Alam and Uddin, 1998; Piferrer, 2001). *Clariid* sp. are very popular because of their easy-to-culture characteristics which have endeared the species to many fish farmers (Asuwajuet *et al.*, 2014). Some male *Clariid* broodstocks are seen with immature testes (Robert *et al.*, 2019b). The report from this research will serve to inform therefore, the effects of testosterone propionate on the growth of *Clarias gariepinus* while detailing the optimal dosage most effective in the sex-ratio determination in *Clarias gariepinus*, to favour the males.

Materials and methods

Study area, source of experimental fish and water source

The study was carried out using the outdoor concrete tanks of the National Institute for Freshwater Fisheries Research (NIFFR), New Bussa, Niger State, New Bussa is located at 9°53'N 4°31'E coordinates (Robert *et al.*, 2019a). Fry of *Clarias gariepinus* were obtained from the hatchery unit of NIFFR New Bussa. NIFFR's Kigera Dam supplied water for this research.

Experimental design

Experimental design was a completely randomized design.

Experimental procedure

Mature female broodstocks of *Clarias gariepinus* were selected based on their external features: swollen and well distended abdomen, reddish vent, soft release of greenish eggs when abdomens were pressed. Mature male broodstocks with reddish pointed genital papillae were also selected. Male and female *Clarias gariepinus* were

weighed separately using a HANA 50kg weighing balance. The females were injected with ovaprim 0.5ml per kg according to their body weight. This injection will be done intramuscularly above the lateral line towards the tail. The males were injected with 0.25ml of ovaprim per kg according to the fish' body weight. After injection, the fishes were kept back in their holding receptacles for the twelve hours latency period. After the twelve hours latency period, the milt was obtained from the male who was sacrificed. Then the females were brought out of their holding receptacles, cleaned and their abdomens pressed to release the eggs. The testes were dissected using a razor blade, the milt squeezed out and then 0.9% of saline solution (NaCl) added to the milt, which was then stirred to aid fertilization. The milt was then poured on the eggs and fertilized. On the seventh day after induced breeding, fry was transported to the outdoor concrete tanks. There were monthly manual exchange of water in the water tanks. Fry were fed with 0.7mm, 2mm and 4mm Ecofloat from the first month to the fourth month; twice a day for 121 days duration according to their body weight. Every month during sampling, fish genital papillae were checked with the aid of a biological microscope (XS Series 500) to ascertain sex change.

Preparation of hormone treated feed

The hormone Testosterone propionate or testosterone 17 β -propanoate (written abbreviately as C17 β propionate), used in this study, was purchased from Ilesanmi Engineering in New Bussa. Its local trade name was given as sustanon 250mg/ml. It was in oily form. The hormone testosterone, was dissolved in 250ml ethanol. This was the stock solution. The stock solution were drawn out using a syringe and a needle of 125mg, 100mg, 75mg, 50mg and 25mg of hormone spread on each bag of 50kg of feed. Feed was aired under room temperature for 24 hours before being used. Fry in the control tanks T₀ had no hormone in their feed.

Growth parameters

$$\% \text{ survival} = \frac{\text{number of broodstock study at the end of study}}{\text{number of juveniles stocked at the beginning of study}} \times 100$$

(Coulbaly *et al.*, 2007; Yisa *et al.*, 2010; Pauly, 1980; Bargenal, 1978).

$$\text{Specific Growth Rate \% day (SGR)} = \frac{\log_e \text{final weight} - \log_e \text{initial weight}}{\text{time (days)}} \times 100$$

(Bake *et al.*, 2014; Von Bertalanffy, 1938).

$$FCR = \frac{\text{Total weight of dry feed offered}}{\text{Total weight gain}}$$

(Sveieret *et al.*, 2000; Wijkstrom and New, 1989).

$$PI = \frac{\text{Survival rate} \times \text{final mean weight (g)} - \text{initial mean body weight (g)}}{\text{Rearing during in days}}$$

(Yakubu *et al.*, 2014; Munro and Pauly, 1983).

Physico-chemical parameters

Measured at stocking till last sampling were: pH, DO, Water temperature, Conductivity.

Data analyses

Data collected during this experiment were subjected to statistical analysis using SPSS version 25.0. Duncan Multiple Range Test (DMRT) was used for mean separation and the differences were determined at level of significance ($p < 0.05$) (Duncan, 1955). Data was also subjected to analysis for regression.

Results

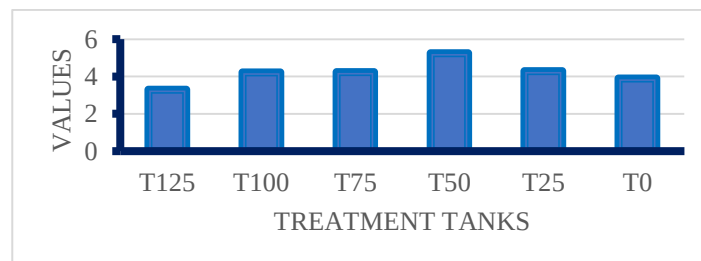


Figure 1: Growth patterns of *Clarias gariepinus* fry fed with feed mixed with testosterone propionate

Table 1: Length-Weight Relationship Regression of *Clariasgariepinus* fed with testosterone propionate in concrete tanks

Treatments	Intercept (a)	Slope (b)	Regression square(R ²)
T ₁₂₅	0.10	1.18	0.61
T ₁₀₀	0.32	1.26	0.93
T ₇₅	0.35	1.46	0.91
T ₅₀	0.37	1.45	0.95
T ₂₅	0.36	1.43	0.80
T ₀	0.37	1.32	0.78

Table 2: Water Quality Parameters of *Clariasgariepinus* treated with testosterone propionate in concrete watertanks

Parameters	T ₁₂₅	T ₁₀₀	T ₇₅	T ₅₀	T ₂₅	T ₀
DO (ppm)	5.53±0.32 ^{a,b}	5.5±0.20 ^{a,b}	5.4±0.20 ^{a,b}	5.93±0.47 ^b	5.07±0.21 ^a	5.00±0.20 ^a
Water temp °C	27.5±0.00 ^a	27.5±0.00 ^a	27.5±0.00 ^a	27.5±0.00 ^a	27.5±0.00 ^a	27.5±0.00 ^a
ØH	7.5±0.10 ^b	7.2±0.1 ^a	7.43±0.06 ^b	7.37±0.15 ^{a,b}	7.43±0.12 ^b	7.47±0.06 ^b
TDS (mg/l)	21.0±7.21 ^a	19.33±1.53 ^a	20.67±0.58 ^a	24.67±1.53 ^a	24.67±3.22 ^a	24.0±1.00 ^a
CONDUCT (µS/cm)	19.0±1.00 ^a	25.00±3.61 ^b	24.00±3.61 ^b	25.67±1.53 ^b	25.67±2.31 ^b	25.33±2.52 ^b

Means in the same row (for each section) with different superscript are statistically different (P<0.05).

Discussion

There was a significant difference ($p < 0.05$) in growth for fry fed with the highest doses of testosterone propionate or testosterone 17 β -propanoate (written abbreviately as C17 β propionate) as seen in T₁₂₅ and T₁₀₀ tanks. There was no significant difference ($P > 0.05$) in growth of fry receiving medium doses of testosterone propionate as seen in T₇₅ and T₅₀. The b-values in this study indicated *Clariasgariepinus* grew negatively allometric with values less than 3, in agreement with Robert *et al.*, (2020) who reported b-values of 0.92, 0.86 and 0.89 for stagnant water culture and 0.82, 0.80, 0.89 for flow-through water culture. In the fourth month, *Clariasgariepinus* fingerlings in the various treatment tanks were seen to have more males than females except for T₁₂₅ which recorded more females instead of males. This suggests that higher doses of fish did not produce higher sex-reversal in favor of males as most sex-reversal were noticed in T₁₀₀, T₇₅ and T₅₀. This result agreed with Alam and Uddin (1998). Chandra and Jhan (2010) recorded condition factor for *Channa punctata* in the range of 1.05-1.89 which agreed with the values in this study.

Conclusion

Findings in this study support that high doses of hormone do not induce so much growth but interfere with normal processes which could include retarded growth and mortality. The addition of hormones in feed is termed most efficient when using optimal dosages for sex-reversal. Optimal dosage for all-male sex reversal from this study ranged from 100, 75 to 50.

References

- Alam, M.S. & Uddin, M.Z. (1998). Effects of testosterone propionate on growth, survival and sex-ratio of African Catfish (*Clariasgariepinus* Burchell). *Bangladesh Journal of Fish Research*, 2(1): 31-39.
- Bargen, T.B. (1978). Effect of nematode infection on the breeding potential of *Clariasgariepinus*. *Journal of Agriculture, Forestry and the Social Sciences*, 8: 141-147.

- Asuwaju, F.P., Onyeché, V.O., Ogbuebunu, K.E., Maradun, H.F. & Robert, E.A. (2014). Effect of feeding frequency on growth and survival rate of *Clarias gariepinus* fingerlings reared in plastic bowls. *Journal of Fisheries and Aquatic Science*, 9(5):425-429.
- Bake, G.G., Martins, E.I. and Sadiku, S.O.E. (2014). Nutritional evaluation of varying levels of cooked flamboyant seed meal (*Delonix regia*) on the growth performance and body composition of Nile Tilapia (*Oreochromis niloticus*) fingerlings. *Agriculture, Forestry and Fisheries*. 3(4): 233-239.
- Chandra, R. & Jhan, N. (2010). The analysis of the length-weight relationship of *Channa punctatus* with relative physico-chemical parameters. *Journal of Expository Science*, 2010, 1(5):4-5.
- Coulibaly, A., Outtara, I.N., Kone, T., N'Douba, V., Snoeks, J., Goore Bi, G. & Kouamelan, E.P. (2007). First results of floating cage culture of the African Catfish *Heterobranchius longifilis*. Valenciennes, 1840: Effect of stocking density on survival and growth rates, Univerite de Cocody-Abidjan, *Journal of Aquaculture*, 263: 61-67.
- Duncan, D.B. (1955). Multiple range and multiple F-Test biometrics, 11(1):1-42.
- Megbowon, I., Fashina-Bombata, H.A., Mojekwu, T.O. & Okuade, O. A. (2009). Genetic improvement of tilapia: Challenges and prospects in Nigeria. *Nigerian Journal of Fisheries*, 6:21-30.
- Megbowon, I. & Mojekwu, T.O. (2014). Tilapia sex reversal using Methyl-Testosterone (MT) and its effects on fish, man and environment. *Biotechnology*, 13:213-216. doi:10.3923/biotech.2014.213.216
- Munro, J.L. & Pauly, D. (1983). A simple method for comparing growth of fishes and invertebrates, *ICLARM Fishbyte*, 1:5-6.
- Pauly, D. (1980). On the interrelationships between natural mortality, growth parameters and mean environmental Temperature in 175 fish stocks. *Journal du Conseil/Conseil Permanent International pour l'Exploration de la Mer (International Council for the Exploration of the Sea)*, 39(2), 175-192.
- Piferrer, F. (2001). Endocrine sex control strategies for the feminization of teleost fish. *Aquaculture*, 197:229-281.
- Robert, E.A., Yisa, A.T. & Tsadu, S.M. (2019a). Growth performance and survival of monosex cultured *Heterobranchius longifilis* juveniles in concrete flow-through and stagnant water systems. *Scientific Research Journal (SCIRJ)*, 7(2): 43-65. doi: 10.31364/SCIRJ/v7.i2.2019.P0219615
- Robert, E.A., Onyeché, V.O., Ovie, S.O., Binyotubo, O., Ekundayo, T. & Ofor, C.C. (2019b). Growth, survival and reproductive success of *Clarias gariepinus* broodstocks fed feed mixed with 17 α -Methyl Testosterone (MT) in stagnant concrete systems. *Scientific Research Journal (SCIRJ)*, 7(3): 17-32. doi: 10.31364/SCIRJ/v7.i3.2019.P0319620.
- Robert, E.A., Onyeché, V.O., Ovie, S.O. (2019c). Effect of 17 α -Methyl Testosterone (MT) on all-male sex reversal and determination, growth and survival of *Clarias gariepinus* juveniles in concrete stagnant systems. *Scientific Research Journal (SCIRJ)*, 7(3): 105-118. doi: 10.31364/SCIRJ/v7.i8.2019.P0819691
- Robert, E.A., Yisa, A.T. & Tsadu, S.M. (2020). Growth performance of monosex cultured *Clarias gariepinus* juveniles in concrete flow-through and stagnant water tanks. *Proceedings of the 35th Annual National Conference of FISON (MINNA 2020)*. Held at Raw Materials Research and Development, Abuja 15th November-19th November, 2020. pp.53-56.
- Sveier, H., Raae, A.J. & Lied, E. (2000). Growth and protein turnover in Atlantic salmon (*Salmo salar* L.): the effect of dietary protein level and protein particle size, *Aquaculture Research*, 33:1233-1242.
- Von Bertalanffy, L. (1938). A quantitative theory of organic (inquiries on growth laws II), *Human Biology*, 10, 181- 213.
- Wijkstrom, U.N. & New, M.B. (1989). Fish for feed: a help or a hindrance to aquaculture in 2000? *INFOFISH International*, 6(89), 48-52.
- Yakubu, A.F., Nwogu, N.K., Olaji, E.D., Ajiboye, O.O., Apochi, J.O., Adams, T.E., Obule, E.E. & Eke, E. (2014). A comparative study on growth performance and survival rate of *Clarias gariepinus* (Burchell, 1822) and *Heterobranchius longifilis* Valenciennes, 1840 under water recirculation system, *Agriculture, Forestry and Fisheries Journal*, 3(1): 30-33.
- Yisa, T.A., Tsadu, S.M. & Musa, A. (2010). Effect of nematode infection on the breeding potential of *Clarias gariepinus*. *Journal of Agriculture, Forestry and the Social sciences*, 8:141-147.

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Genetic Diversity of Nile tilapia (*Oreochromis niloticus*) from Three Different Ecological Populations Using Mitochondria Cytochrome c 1 Oxidase (CO1) DNA Marker

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Abstract

DNA markers are increasingly used in related studies of population genetics, characterization and conservation biology of fish species. This study was carried out to characterize Nile tilapia (*Oreochromis niloticus*) from three different ecological populations using mitochondria cytochrome c 1 oxidase (CO1). A total of twenty one (21) sample specimens comprising of seven (7) specimens each of Nile tilapia (*O. niloticus*) were sourced from Federal University Agriculture Abeokuta (FUNAAB) Reservoir (FRP), Owena River (ORP), and Eleyele Dam (EDP) populations. Blood samples were collected from the fish specimens for DNA extraction using Norgen's DNA isolation kit. The gene locus of Mt-CO1 was amplified in Polymerase chain reaction assay using Mitochondrial (CO1) gene primers with the aid of Bio-rad cycler. Nt sys was used to analyse the amplicons for similarity index. The amplification of the DNA template generated banding pattern for ORP and EDP, however there was smear and non-amplification in FRP populations using the COI primer. Base pair bands were generated at 700bp for ORP and EDP indicating the population's similarity. The study concluded by validating the efficacy of CO1 in barcoding of *O. niloticus* and possibility of gene high diversity of *O. niloticus* in the populations studied.

Keyword: Cytochrome c 1 oxidase, Marker, Nile tilapia, populations, similarity

Introduction

Genetic marking and identification of fish species, strains, lines, populations, and individuals is very important not only for aquaculture and hatchery operations, but also for capture fisheries management. Genomic technologies have the capacity to provide "diagnostic kits" to identify many important species and populations, using DNA marker technologies (Liu and Cordes, 2004). This is particularly important for fish species and stocks that are captured by humans, because some fisheries might be depleting wild fish genetic resources. In spite of the world's rich piscine diversity, practically much attention has not been paid to stock assessment, sustainable utilization and conservation of these species (Shajiet *al.*, 2000). Furthermore, aquaculture has altered the genetic diversity of many fish populations. Also thousands of wild fish species populations have been extirpated by pollution, over exploitation, destruction of habitat, blockage of migration routes and other human developments (Ferguson, 1995). For these reasons, molecular genetic research should be strongly supported, for it is vital to the long-term management of fisheries resources (Park and Moran, 1995). Polymerase chain reaction is based on using the ability of DNA polymerase to synthesize new strand of DNA complementary to the offered template strand using single specific primer. The protocol usually produces informative bands with without artifactual bands that can be used to describe population's level of similarity (Lamboy, 1994). *Oreochromis niloticus* has emerged as the most cultured food fish species in Africa and second in Nigeria by volume (FAO, 2018). Enhancing its production requires the genetic status studies of various populations. This article addressed the basics of molecular genetics with an emphasis on similarity index of the various populations using data generated from Polymerase Chain Reaction (PCR) assay from mitochondrial cytochrome oxidase 1 gene locus.

Materials and Methods

Sample Fish Collection and Blood extraction

The twenty one (21) Nile tilapia (*Oreochromis niloticus*) fish samples comprising of seven (7) from each population were sourced from: Federal University of Agriculture, Abeokuta (FUNAAB) Reservoir (FRP), Owena River (ORP), and Eleyele Dam (EDP). The fish samples were transported in three (3) twenty five (25) litres keg to the Wet Lab of the Aquaculture and Fisheries Management department where blood samples were collected using 5ml syringe inserted into the skin just after the genital opening into the vertebral bone. The drawn blood samples were put into

EDTA bottles that have been rinsed with EDTA reagent to prevent clotting and transported to Biotechnology Laboratory centre of the Federal University of Agriculture, Abeokuta (FUNAAB), for DNA extraction.

DNA Extraction procedures

Genomic DNA was extracted from 100 µl whole blood using DNA kit (Norgen Canada) following manufacturer instruction (www.norgenbiotech.com). The quality and the quantity of the extracted DNA were measured using NanoDrop 2000C (Thermo Fisher Scientific Inc., Wilmington, USA). It was also measured using gel electrophoresis. The integrity of DNA extracted was assessed by gel electrophoresis using Smith *et al.* (2003) procedures.

Procedures for PCR assay using cytochrome oxidase 1 (CO1) gene.

PCR assay, targeting Pryial region of cytochrome oxidase gene was carried out using a mini cycler (Bio-Rad, USA) in a final volume of 20 µl containing equivalent of 20 ng of genomic DNA, 10 µl of 2 x PCR Master Mix (SydLabs, USA), 8 µl nuclease free water and 0.5 µl (40 ng) each of the forward and reverse of each of the primer sets as designed by Ward *et al.* (2005) *P1* (5'-TCAACCAACCACAAAGATTGGCAC-3') and (3'-GATCACACCGGTTTCACCACTAAC-5') respectively for CO1 region. Amplification conditions were: 94° C for 5 minutes, 45 cycles of 94° C for 30 s, 55° C for 60 s and 72° C for 30s, with final extension at 72° C for 10 minutes. 10 µl of the PCR products were electrophoresed through 1% agarose gel stained with ethidium bromide (Amresco, USA) in 1 x TAE buffer and visualized on UV transilluminator (Spectroline, USA). NTsys was used to analyse the amplicons for similarity index and diversity.

Results

DNA Extraction Result

The details on Table (1) showed that FRP had the least mean of purity levels. Also, the gel image according to Figures 1 and 2 indicated the presence of extracted DNA in all the sampled populations.

Table 1: DNA Concentration and purity levels of the Twenty (21) samples of the Nile tilapia (*Oreochromis niloticus*) using Nano spectrophotometric Quality Test.

Sample location	Conc./Purity Level	Range	Mean	± Std. Error
FRP	Conc. Levels (nm)	13.40 - 200.30	96.17	15.80
	Purity Levels (µg/ml)	0.99 - 1.90	1.68	0.056
ORP	Conc. Levels (nm)	16.00 - 198.50	90.38	12.58
	Purity Levels (µg/ml)	1.51 - 2.11	1.77	0.03
EDP	Conc. Levels (nm)	33.40 - 200.40	92.10	11.64
	Purity Levels (µg/ml)	1.54 - 1.90	1.78	0.027

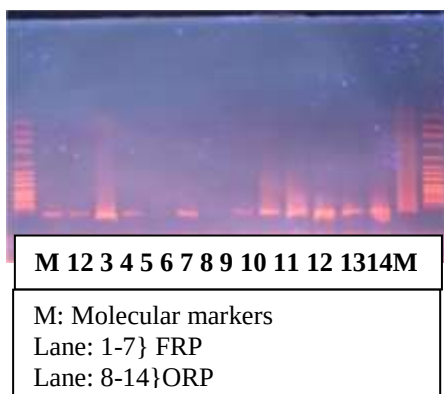


Figure 1: The gel image of samples 1-14 from EDP representing the populations from FRP and ORP

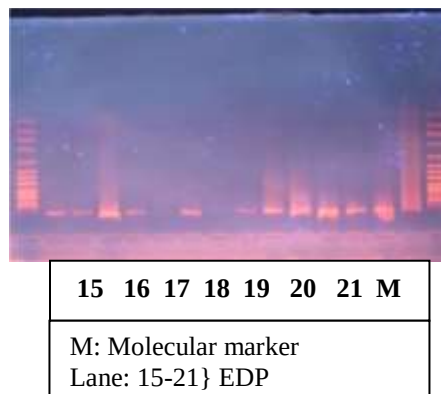


Figure 2: The gel image of samples 15-21

Furthermore, the point of base pair amplification (700 bp), in the present study differed from the result of Zhang and Hewitt (1996) range of (600 – 750bp) but in line with (Folmer *et al.*, 1994) result (710 bp) of the control region. The similarity and dissimilarity values according to the total length of base pairs had ORP and EDP similar. The varied results from the population's similarity index indicated a high and lower diversity with values from 1.00000 to 0.20000 respectively. According to Wang *et al.* (2007) genetic diversity is needed for the sustenance of fish populations. Thus, sample species and populations with high similarity index belonging to different geographical locations suggest that the individuals in the population have close genetic relation among them (Lambooy, 1994). This scenario occurs in natural populations when there is a possibility of hybridization and random mating among fish species. This result is in agreement with Ceruso *et al.* (2020) *Sparidia* species barcoding among different isolated populations. It is important to note that FRP had once had some cages and pens in it where different species of tilapia are reared. It is possible that they might have been some unintentional release and escape of the exotic species, thus making the population of *O. niloticus* heterogeneous.

Conclusion

The study affirmed mitochondria cytochrome c oxidase 1 as a potential marker for barcoding and similarity index studies of *O. niloticus* from the different populations. It also, validated the region of amplification and its corresponding annealing temperature and base pairs for the three ecological populations. Although, two (ORP and EDP) of the three populations appeared similar there is tendency that they might not be genetically related. Also, the genetic diversity of the populations appeared divergent due to low and high diversity levels.

References

- Ceruso, M., Mascolo, C., De Luca, P., Venuti, I., Smaldone, G., Biffali, E. and Sordino, P. (2020). A rapid method for the identification of fresh and processed *Pagellus erythrinus* species against frauds. *Foods*, 9(10), 1397.
- FAO (2018). The State of World Fisheries and Aquaculture (SOFIA) - Meeting the Sustainable Development Goals, Food and Agriculture Organization, Rome, Italy (2018) (p. xiii + 210).
- Ferguson, A. J. B. T., Taggart, J. B., Prodöhl, P. A., McMeel, O., Thompson, C., Stone, C. and Hynes, R. A. (1995). The application of molecular markers to the study and conservation of fish populations, with special reference to *Salmo*. *Journal of Fish Biology*, 47, 103-126.
- Folmer, O., Black, M., Hoeh, W., Lutz, R., and Vrijenhoek, R. (1994). DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. *Molecular Markers of Biology and Biotechnology* 3: 294–299.
- Gallagher, S.R. (1992). Quantitation of DNA and RNA with absorption and fluorescence spectroscopy, p. A3-5 to A3-8. In F.M. Ausubel, R.E. Kingston, D.D. Moore, J.G. Seidman, J.A. Smith and K. Struhl (Eds.), *Current Protocols in Molecular Biology*, Vol. 3. John Wiley and Sons, New York.
- Gallagher, R. E., Li, Y. P., Rao, S. R. E. E. N. I. V. A. S., Paietta, E., Andersen, J., Etkind, P. and Wiernik, P. H. (1995). Characterization of acute promyelocytic leukemia cases with PML-RAR alpha break/fusion sites in PML exon 6: identification of a subgroup with decreased in vitro responsiveness to all-trans retinoic acid, 1540-1547.
- Lambooy, W. F. (1994). Computing genetic similarity coefficients from RAPD data: correcting for the effects of PCR artifacts caused by variation in experimental conditions. *Genome Research*, 4(1), 38-43.
- Liu, Z.J. and Cordes, J.F. (2004). DNA marker technologies and their application in aquaculture genetics. *Aquaculture* 238: 1-37.
- Park, L. K., and Moran, P. (1995). Developments in molecular genetic techniques in fisheries. In *Molecular genetics in fisheries* (pp. 1-28). Springer, Dordrecht.
- Shaji, C. P., Easa, P. S., and Gopalakrishnan, A. (2000). Freshwater fish diversity of Western Ghats. Endemic Fish Diversity of Western Ghats. NBFGR-NATP publication, National Bureau of Fish Genetic Resources, Lucknow, India, 347pp, 33-35.
- Smith, K., Diggle M.A, Clarke S.C. (2003). Comparison of commercial DNA extraction kits for extraction of bacterial genomic DNA from whole-blood samples. *Journal Clinical Microbiology*, 41: 2440–2443.
- Wang, W. Chen. L. Yang, P. Hou, L. He, C. Gu, Z. and Liu, Z. (2007). Assessing genetic diversity of populations of top mouthculter (*Culter alburnus*) in China using AFLP markers. *Biochemistry of Systematic Ecology*, 35, 662–669.
- Ward, R. D., Zemlak T.Z., Innes B.H., Last P.R., Hebert P. D. N. (2005). DNA barcoding Australia's fish species. *Philosophical Transactions of the Royal Society B* (2005). 360, 1847–1857.
- Zhang, D.X. and Hewitt, G.D. (1996). Nuclear integrations: challenges for mitochondrial DNA markers. *Trends Ecology Evolution* (Amst.). 11:247–251.

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Effects of Incubation Time on Quality and Quantity of DNA from Fish**Usman A.B, Oguntade O.R, Oketoki T. O, Ukenye E.A, Sokenu B.A, Adeleke R.O and Joseph J.B**Department of Biotechnology, Nigerian Institute for Oceanography and Marine Research, Ahmadu Bello way Victoria Island, Lagos. Lagos State.; Corresponding Author: adesbabe2000@yahoo.com**Abstract**

Manual method of DNA extraction has certainly come a long way over time to achieve good quality DNA; which require repeated centrifugation steps, followed by removal of supernatants depending on the type of specimen and additional mechanical treatment. In regards to this, an attempt was made to compare the different incubation times on DNA quality during DNA extraction using phenol-chloroform-isoamylalcohol protocol. In this study, tilapia tissue of approximately 25-50mg was used. Incubation times were varied by 1 hour, 2 hours, 6 hours and 12 hours (overnight) at the incubation step. Quantification of the DNA were obtained using Nano drop spectrophotometer at 260/280 wave-length and Agarose gel electrophoresis at 0.8% concentration was carried out to visualize and ascertain the Isolate DNA. The result showed that incubation time at 12hrs had a good yield (92.9ul - 224.9ul); purity (1.72 - 1.94) and distinct bands. Therefore, increase in incubation at 12hrs during extraction of fish samples can increase the yield, quality and quantity of DNA for molecular analysis.

Keywords: DNA, extraction, Incubation times, Fish quality.

Introduction

The extraction and purification of high-quality DNA from fish is generally difficult to obtain due to the presence of polysaccharides, proteins, and DNA polymerase inhibitors such as tannins, alkaloids, and polyphenols. The presence of these compounds affects the quality and quantity of isolated DNA, and therefore, renders the sample non-amplifiable (Sarwat *et al.*, 2006). Recently, Polymerase Chain Reaction (PCR) method has been widely applied in modern studies of genetics for detecting diversity within and among populations. In Biotechnological research, isolating good nucleic acid (DNA and RNA) are of importance (both quality and quantity) this is a prerequisite and important step for subsequent steps in molecular analysis (Kumari, *et al.* 2012). According to Ukenye *et al.* (2012) Phenol-chloroform Isoamyl alcohol as one of the best DNA extracting solution for both fresh and frozen fish tissues. One of the most commonly used methods to estimate nucleic acid concentration, purity and presence of contaminants in the biological samples during DNA extraction process is the measurement of sample absorbance at 260/280 nm using nano-spectrometer (Gallagher, 1994). This study was done to assess the concentration of extracted fish DNA (Tilapia species) using a modified phenol-chloroform Isoamylalcohol at different incubation times for a comparative study.

Materials and Methods**Sampling**

A total of 40 freshly harvested adult Tilapia fish samples were obtained at Biotechnology Department of Nigerian Institute of Oceanography and Marine Research experimental research ponds.

DNA Extractions

Approximately 25-50mg of fresh tissues from the ventral region were collected and weighed into 1.5ml micro-Eppendorf tube. A total number 40 samples were extracted using method of modified phenol-chloroform isoamylalcohol method extraction (Sambrook and Russell, 2001).

Phenol Chloroform Isoamyl Alcohol Protocol

Average weight of 25-50mg of fish flesh (40 samples) were weighed inside each of 1.5ml Eppendorf tubes. 550ul volume of lysis buffer (50mM Tris-HCl, pH 8.0, 0.5mM EDTA pH 8.0, and 100mM NaCl), 10ul of enzymes which are Proteinase K and RNase were added to the tissue's samples. The Eppendorf labeled 1-10 were incubated for 1hr; 11-20 for 2hrs; 21-30 for 6hrs and 31-40 for 12hrs respectively. After each of incubation time, the lysis was stopped by adding 200ul of ammonia acetate and 250ul of phenol-chloroform-isoamyl alcohol was added two times; centrifuged and decanted into new tubes twice. The DNA obtained was precipitated with 750ul of cold

absolute ethanol and incubated in freezer over-night. The pellet was obtained by centrifuging at 12,000rpm for 10mins and washed with 700ul of 70% ethanol. The pellets were air dried and re-suspended with 100ul of TE buffer and finally stored in -20°C.

Spectrophotometer Analysis and Electrophoresis

A common method to determine the purity and concentration of biomolecules from sample isolates is by use of a spectrophotometric ratio using absorbance measurements at wavelengths of 260 nm and 280 nm and visualization of the DNA bands on gel electrophoresis. In this study, the quality and quantity of DNA obtained were determined by spectrophotometer with absorbance of 260/280 and visualization of the band on gel electrophoresis. The concentration of the DNA was achieved using nanospectrophotometer which was blank by TE buffer and 1ul of DNA used to determine the concentrations. The electrophoresis was carried out on 0.8% agarose gel; ran with 1XTBE buffer at 80V for 60mins. The gels were stained with ethidium bromide, viewed with UV transilluminator and image captured by camera.

Results and Discussion

In this study, different incubation times were used to compare the purity and concentration of DNA. The results obtained on DNA purity and concentrations (yield) were summarized in Table 1, 2, 3 and 4; while Plates 1, 2, 3 and 4 showed the band viewed on gel electrophoresis following different incubation periods. From the results table 4, it showed that the samples incubated at 12hrs gave more of yield between 92.9ul - 224.9ul and the purity was between 1.72 - 1.94 which showed a good DNA product compared to 1hr incubation time concentrations of 43.2ul - 140.5ul and purity were 1.63-2.40; 2hrs incubation time concentrations were 80.8ul-225.5ul and purity were 1.88-2.44; and 6hrs incubation concentrations were 57.6ul -170ul and purity were 1.76-1.99 respectively. Figure 4, also showed a clearer gel picture with a good quantity of DNA which was incubated for 12hrs. Extraction using phenol-chloroform isoamyl alcohol for fresh samples (Ukenyeet *et al.*, 2012) which was incubated for 12 hrs showed a better yield and distinct bands on agarose electrophoresis. This is in accordance with Tweedie and Stowell (2005) and Ahnet *et al.* (1996) who use the gel electronic imaging for accurate determination of DNA mass. Also, DNA quantification using nanospectrophotometer. Therefore, this study revealed that incubation of fish tissue at 12hrs gave a reliable good quality and quantity of DNA for further molecular analysis.

Table 1.0: Concentration and Purity of 1hr Incubation period of DNA

Sample	Conc.(ng/ul)	Purity(A260/A280)
1	94.5	1.87
2	120.4	1.81
3	150.4	1.98
4	60.3	2.19
5	65.8	2.40
6	64.1	2.28
7	74.7	2.19
8	140.5	1.63
9	93.1	1.77
10	43.2	1.63

Table 2.0: Concentration and Purity of 2hr Incubation period of DNA

Sample	Conc.(ng/ul)	Purity (A260/A280)
1	222.5	1.91
2	93.5	1.88
3	120.3	1.93
4	80.8	1.94
5	167.7	1.90
6	147.8	2.44
7	173.5	1.69
8	131	1.92
9	54.2	1.93
10	274.4	1.75

Table 3.0: Concentration and Purity of 6 hr. Incubation period of DNA.

Sample	Conc.(ng/ul)	Purity (A260/A280)
1	84.3	1.99
2	160.3	1.91
3	57.6	1.95
4	43.0	1.93
5	82.2	1.76
6	82.2	1.76
7	169	1.89
8	172	1.85
9	170.3	1.83
10	168.0	1.85

Table 4.0: Concentration and Purity of 12 hr. Incubation period of DNA.

Sample	Conc.(ng/ul)	Purity (A260/A280)
1	92.9	1.73
2	160.6	1.82
3	140.6	1.89
4	120.4	1.86
5	120.9	1.89
6	110.8	1.94
7	224.9	1.78
8	44.8	1.86
9	93.4	1.72
10	213.3	1.76

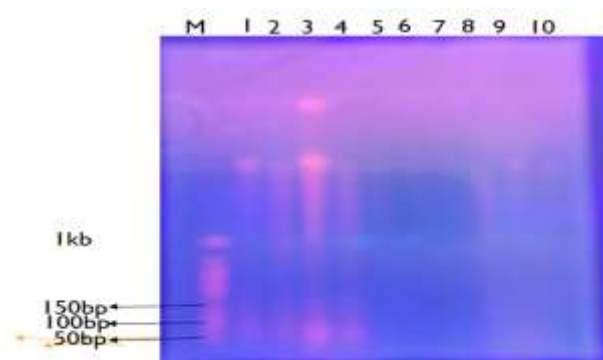


Plate 1: Picture of One hour Incubation period of DNA samples on 0.8% Agarose gel Electrophoresis

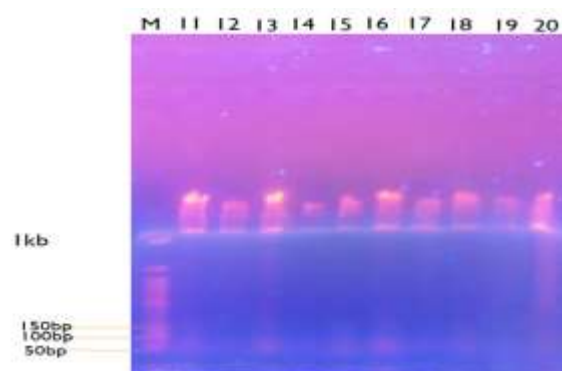


Plate 2: Picture for Two hours Incubation period of DNA samples on 0.8% Agarose gel electrophoresis

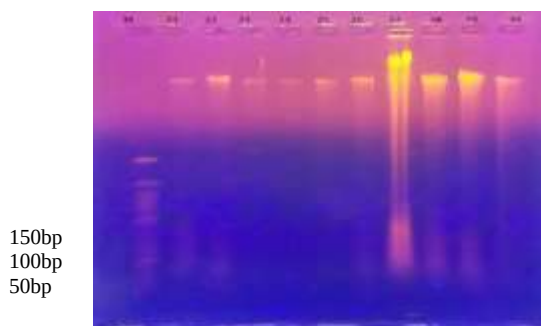


Figure 3: Picture for Six hours Incubation period of DNA samples on 0.8% Agarose gel Electrophoresis

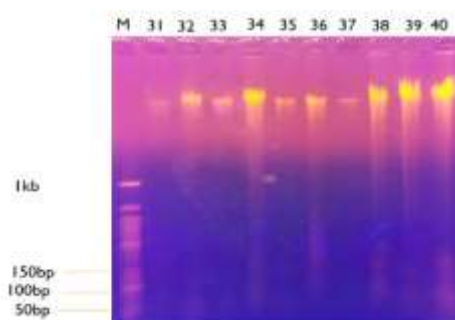


Figure 4: Picture for twelve hours Incubation period of DNA samples on 0.8% Agarose gel Electrophoresis

Conclusion

The use of modified phenol- chloroform isoamyl alcohol protocol for extraction (Sambrook and Russell, 2001) has been used as a method for extraction of DNA from animal tissue, it has been modified several times to reduce contaminants such as polyphenols and polysaccharides that are present in the animal tissues. Although all currently published methods of DNA extraction have demonstrated their effectiveness in isolating DNA that is suitable for PCR amplification or restriction digestion. Therefore, this current study showed long incubations at 12hrs, multiple precipitation steps, and ethanol washes to produce RNA-free genomic DNA of high purity. These additional manipulations produced large amounts of high quality and quantity of DNA for further molecular analysis.

References

- Ahn, S.J., Costa J. and Emanuel J.R (1996). PicoGreen quantitation of DNA: effective evaluation of samples pre- or post-PCR, *Nucleic Acids Res.* 24 (1996) 2623–2625
- Gallagher S. R. (1994). Quantitation of ADN and ARN with absorption and fluorescence spectroscopy,” *Current Protocols in Human Genetics*, vol. 0, no. 1, pp. A.3D.1–A.3D.8, 1994.
- Kumar M, Bijo A.J., Baghel R.S., Reddy C.R.K. and Bhavanath J. (2012). Selenium and spermine alleviate cadmium induced toxicity in the red seaweed *Gracilaria dura* by regulating antioxidants and DNA methylation. *Plant Physiology and biochemistry* 51:29-128
- Ukenye E, Oguntade O., Mojekwu T., Oketoki, T. and Usman A. (2012). Comparison of DNA Extraction from Fresh and Frozen samples using different Extraction Protocols. 25th Annual Conference of The Biotechnology Society of Nigeria. Pp 140-143.
- Sarwat M, Negi M, Lakshmikumaran M and Tyagi A (2006). A standardized protocol for genomic DNA isolation from *Terminalia arjuna* for genetic diversity analysis. *Electron J Biotechnol.* 9:86–91.
- Sambrook J. and Russell D. (2001). *Molecular Cloning: A Laboratory Manual*, 3rd edn. Cold Spring Harbor, NY: Cold Spring Harbour Laboratory Press.
- Tweedie, K.M and Stowell J.W (2005). Quantification of DNA by agarose gel electrophoresis and analysis of the topoisomers of plasmid and M13 DNA following treatment with a restriction endonuclease or DNA topoisomerase I, *Biochem. Mol. Biol. Educ.* 33:28–33.

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Efficacy of Different Concentrations of Saline Solution in Milt Dilution on Fertilization, Hatchability and Survival of African Catfish (*Clarias gariepinus*) Burchell (1822)

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Abstract

The study was carried out at the fish production unit of Federal College of Agriculture Ishiagu, Ebonyi State to determine the effect of different saline levels in milt dilution on the fertilization, hatchability, and survival of *Clarias gariepinus*. The experiment was laid out in completely randomized design (CRD) with four (4) treatments replicated three times. The saline concentration of each treatment was $T_1=0.45\%$, $T_2=0.90\%$, $T_3=1.35\%$ and $T_4=1.80\%$. Data were collected on fertilization of the egg, hatching of the eggs and survival rate of hatchlings. The data obtained was subjected to one-way analysis of variance (ANOVA). The study revealed a high fertilization rate for T_1 and T_2 at $93.00\pm0.76\%$ and $92.67\pm0.60\%$ respectively, the values were not significantly different ($p>0.05$). There was a higher significant difference ($p<0.05$) in hatchability rate for T_3 ($94.31\pm 1.16\%$) than other treatments while T_2 ($93.97\pm0.43\%$) and T_3 ($93.91\pm0.14\%$) showed high survival rate, they were not significantly different ($p>0.05$). The salt dilution for optimum fertilization, hatchability and survival rate ranged from 0.45% to 1.35%. Higher salt concentration leads to low fertilization and subsequently poor survival rate. Other physico-chemical parameters of the water as well as the physiological status of the brooder fish could possibly play important roles for an optimum output in induced breeding of African catfish *Clarias gariepinus*.

Keywords: Pituitary gland, Milt, Broodstock, Fish seeds, Induced breeding.

Introduction

Fish is the most heavily tended food commodity in the market, with the continuous declining of natural fish production, it is crucial to improve fish production from aquaculture as it is one sector that can significantly contribute to world fish production (Gupta and Acosta, 2001). African catfish was one of the most suitable species in aquaculture. It has been considered to hold a great promise for fish farming; the African catfish having a high growth rate, resistant to handling stress, being very well accepted amongst most tribes and religions as well as commanding a high market value. One key constraint to its culture is the limited availability of quality fingerlings as seed material (Sahoo *et al.*, 2007). Induced spawning has become the major source of fish seed production for the majority of aquaculture species; however, this also have its limitation thereby resulting in fish farmers encountering shortages of fingerlings with which to stock their ponds.

Failure in fertilization and hatching during induced spawning may not always be due to maturity stage of the parent stock fish but could also be due to environmental and other physico-chemical factors such as salinity. Saline solution has been used for storing and preserving isolated animal cells. In induced spawning of African catfish, saline solution is used not only as a carrier of pituitary homogenates, but also as a preservative for the milt. Normal saline containing 9g of sodium chloride (NaCl) in one litre of water is generally assumed to be the ideal saline concentration for fertilization; however, too little or too much saline concentration has a lethal effect on the cells. Nwokoye *et al.* (2007) in a study on Clariid catfish reported that there was the possibility of carry over effects from fertilization to hatchability, and survival of Clariid catfish fry's. Okunsebor *et al.* (2014) reported that high concentration of saline has a lethal effect on the cell which could affect fertilization, hatchability, and survival rate of *Clarias gariepinus*. Okunsebor *et al.* (2014) and Orji *et al.* (1997) also reported that the percentage fertilization increased with increase in volume of normal saline and decreased after a certain volume of normal saline. This has necessitated the need to investigate the use of saline solution of different concentrations on the fertilization and survival of African catfish (*Clarias gariepinus*).

Materials and Methods

Description of Study Area

The research was carried out at the Fish Production Unit of the Department of Fisheries Technology, Federal College of Agriculture Ishiagu, Ebonyi State Ishiagu, Nigeria.

Broodstock Selection and Management

The male (1.0kg) and female (1.2kg) brood stocks of *Clarias gariepinus* were collected from the fish production unit of Federal College of Agriculture Ishiagu, Ebonyi State. The brood stocks were kept and acclimatized in small separate holding tanks for 2 days prior to the breeding exercise according to sexes. The weight of the stocks was determined using weighing balance.

Experimental Design

The experiment was a complete randomized design (CRD) with three replicates. A total of 12 trials were carried out comprising four treatments replicated three times. The treatments were:

T₁=4.5g of salt in 1000ml of water

T₂= 9.0g of salt in 1000ml of water

T₃= 13.5g of salt in 1000ml of water

T₄= 18.0g of salt in 1000ml of water

Extraction of Pituitary Glands

The pituitary gland located inside the skull at an angle of 45° to the fish eye. A triangular cutting was made on the dorsal side of the head and the cut portion removed to expose the brain pan. The pituitary gland was then collected carefully from the ventral side of the brain using a small spatula. Freshly collected pituitary gland from the donor *Clarias gariepinus* was immediately placed in methylated spirit in a specimen bottle to preserve it.

Preparation and Injection of Pituitary Hormone

The pituitary extract was squashed in a mortar, mixed with 2ml of normal saline solution and drawn into a 2ml graduated syringe. Selected female brooders were then injected intramuscularly at an angle of 30-45° i.e between the dorsal fin and the lateral line as described by Olumuji and Mustapha (2012). The injected female was then placed in a water tank in order not to be disturbed till it is ready to be stripped. This may take between 12 and 36 hours depending on the water temperature.

Collection of Milt (Sperm)

The testes were removed from the sacrificed male catfish and cut with a sterile razor blade then squeezed into four different bowls containing about 5ml of the varying level of salt solution.

Stripping of Eggs from Female Brooder/Fertilization and Incubation
The body of the female brooder was mopped dry by the use of towel to prevent the egg from coming in contact with water, because this may consequently seal up the micropyle and prevent fertilization. Pressure was applied gently on the abdomen of the female brooder injected with the pituitary suspensions. The Ovulated eggs was collected into plastic bowls with the aid of a 2ml graduated syringe and labelled properly. Spermatozoa (milt) from the mature male was then used to fertilize the eggs in the labelled bowls. Fertilization was done by pouring the milt on the ovulated eggs and stirring the mixture gently. Incubation of the fertilized eggs was carried out in plastic containers. The fertilized eggs were spread in single layers on a net that was suspended in the water. Hatching was expected to start in 24 hours.

Egg Counting

The egg was measured using a 2ml graduated syringe and spread on a flat surface. The eggs were then carefully counted with the aid of a magnifier to determine the number of eggs in the respective treatments

Determination of Reproductive Success Parameters

After fertilization, dead and unviable eggs which have turned whitish were counted and percentage fertilization was estimated. Percentage hatchability and survival were monitored and calculated at 24±8hrs and the fifth day after hatching respectively using the method of Ndehamet *al.* (2018)

Fertilization Rate

Fertilization rate (%) was calculated using the formular:

$$\frac{\text{Number of fertilized eggs} \times 100}{\text{Number of eggs counted}} \quad 1$$

(Ndehamet *al.* 2018)

Hatchability Rate: Hatchability was determined using the formular

$$\% \text{Hatchability} = \frac{\text{Number of eggs hatched (fry)}}{\text{Number of eggs}} \times 100$$

Number of eggs incubated (Ndehamet *et al.* 2018)

Survival Rate: Survival rate was determined from the formulae

$$\% \text{Survival Rate} = \frac{\text{Final number of fry (after the yolk disappeared)}}{\text{Initial number of fry (with yolk after hatch)}} \times 100$$

(Ndehamet *et al.* 2018)

Data Analysis

Data obtained from each treatment were compared by One-way Analysis of Variance (ANOVA) test using IBM SPSS 23 to determine the significant differences ($p < 0.05$) in reproductive performance parameters.

Result and Discussion

Table 1: Means of percentage fertilization, hatchability, and survival rates of fry's

Parameters	Treatments			
	T ₁ (4.5g)	T ₂ (9.0g)	T ₃ (13.5g)	T ₄ (18.0g)
Fertilization rate (%)	93.00±0.76 ^a	92.67±0.60 ^a	84.00±0.50 ^b	80.67 ±0.44 ^c
Hatchability rate (%)	92.48± 0.76 ^{ab}	94.31 ± 1.16 ^a	87.90 ±0.65 ^c	88.44± 0.97 ^{bc}
Survival rate (%)	90.50 ± 0.50 ^{ab}	93.97 ±0.43 ^a	93.91 ±0.14 ^a	87.88 ±2.17 ^b

All values on the row with different superscript are significantly different ($P < 0.05$)

At the end of the experiment, mean fertilization rate were above 80% as indicated in the Table 1. The lowest mean fertilization was recorded in Treatment T₄ (80.67±0.44) while the highest mean fertilization was recorded in Treatment T₂ (93.67±0.60) and T₁ (93.00±0.76). This conforms with the report of Okunseboret *et al.* (2014) and Ukwuaniet *et al.* (2016) who reported that high concentration of saline has a lethal effect on fertilized egg which could affect fertilization, hatchability and survival rate of *Clarias gariepinus*. This was also similar to what Orji *et al.* (1997) obtained in their result as the highest fertilization was recorded at 0.4% salt concentration. The significant ($p < 0.05$) low fertilization rate obtained in T₃ and T₄ could be attributed to possible shrinking effects on milt as earlier reported by Su *et al.* (2013), in the same vein, developmental changes are adversely hindered with increase in salinity, as observed from the decreasing fertilization rate from T₁ to T₄, the reduction in fertilization rate from T₁ to T₄ could possibly be connected to milt motility which is affected by high salt concentration (Martins *et al.*, 2015). However, the highest mean fertilization was quite higher in this study at 93.67% for T₂ and 93.00% for T₁ than that of Orji *et al.* (1997) at 70%. This might have occurred due to variations in physico-chemical parameters of the water used during the experimental process. This finding implies that fertilization is best carried out with milt mixed with saline solution within the range of 4.5g and 9.0g of salt to 1000ml of water.

The lowest mean hatchability was recorded in T₃ (87.90±0.65) while the highest was recorded in T₂ (94.31±1.16). However, this was found not to be statistically different from values obtained from T₁ (92.48±0.76). The high significant ($p < 0.05$) hatchability rate observed in T₂ showed that the relative low salt concentration in the treatment was optimum for the high hatchability recorded, this was earlier documented by Fashina-Bombata and Busari, (2003) for *Heterobranchus longifilis* and Fridmanet *et al.*, (2012) for Nile tilapia *Oreochromis niloticus*. Though this result is also similar to where the highest hatchability was obtained in this study, values in this study were much higher (94%). This could also be attributed to fluctuations in physico-chemical parameters of the water which changes with metabolic processes of embryonic development and egg-hatching as well as the physiological state of the broodstock fish among many other factors which affect reproduction in catfishes. This finding implies that saline solution of 4.5g salt can be used to substitute normal saline solution (9.0g). However, increase in saline concentration beyond this level could decrease the hatchability levels of the eggs.

Finally, the result of survival rate of fry's in the study showed the highest mean survival in T₂ (93.97±0.43) while the least was recorded in T₄ (87.88±2.17). However, mean survival values obtained in T₂ and T₃ (93.91±0.14) were not statistically different ($p > 0.05$) while the T₁ and T₄ were both significantly different ($p < 0.05$) in their survival rate. The values of T₂ and T₃ is indicative that the ideal salt concentrations for fry survival is within the range of 9.0 to 13.5g of sodium chloride while values outside the range could lead to mortality and subsequent low survival rate as observed in T₁ and T₄ which were recorded in the two extremes. The high survival rate recorded in treatment T₂ was possibly due to high hatching rate and low population of unhatched eggs and reduced pollution and possible microbial infection. Orji *et al.* (1997) also reported that highest survival was recorded at 0.4% saline concentration.

Ukwuaniet *al.* (2016) and Orji *et al.* (1997) also reported that freshwater fish could be affected by high salinity. This could explain why low survival was recorded in treatment T₄. This implies that very good survival would be obtained when saline solution containing salt of 4.5g -13.5g in 1000ml of water is used in milt dilution.

Conclusion

The appropriate sodium chloride dilution is one the prerequisite to a successful induced breeding of African catfish (*Clarias gariepinus*). The study revealed that improved results were obtained when milt was diluted in the range of 4.5g to 13.5g of salt in 1000ml of water while higher salt concentration leads to mortality. However, the current study should further be investigated to ascertain the relationships of different salt concentrations and other water physico-chemical parameters.

Reference

- Fashina-Bombata, H. A. and Busari, A. N (2003). Influence of salinity on the developmental stages of African catfish *Heterobranchus longifilis* (Valenciennes, 1840). *Aquaculture* 224: 213-222
- Fridman, S; Bron, J; Rana, K (2012). Influence of salinity on embryogenesis, survival, growth and oxygen consumption in embryos and yolk-sac larvae of the Nile tilapia. *Aquaculture* 334-337: 182-190,
- Gupta, M. V. and Acosta, B.O (2001). Fish genetic research in member countries and institutions of the international network in genetics in aquaculture. The world fish center, Orissa India P 179.
- Martins, G. B., Piedras, S. R. N., Pouey, J.L. O. F., Bongalhardo, D. C. and Robaldo, R. B (2015) Salinity on artificial reproduction of silver catfish (*Rhamdia quelen*) *Ciência Rural* 45(3): 458-463
- Ndeha, V.R., Ladu, B.M.B and Onyia, L.U. (2018). Comparison of Fertilization, Hatchability, Growth and Survival of *Clarias Gariepinus* from Adamawa and Katsina States. *Advances in Life Science and Technology*. 63: 1-7
- Nwokoye, C.O., Nwuba, L.A., Eyo, J.E. (2007). Induced propagation of African clariid catfish, *Heterobranchus bidorsalis* (Geoffrey Saint Hillarie, 1809) using synthetic and homoplastic hormones. *Afr. J. of Biot.* 6(23): 2687- 2693.
- Okunsebor, S. A., Imgbian, T.D. and Manomi, B. B. (2014). Effect of Different Dilutions of Saline on Some Sperm Parameters and their influence on Fertilization, Hatchability and Survival Rate of Hatchlings of Catfish (*Clarias gariepinus* Burchell, 1822). *Proceedings of the 29th Annual Conference of The Fishery Society of Nigeria*, Markurdi.
- Olumuji OK, Mustapha MK (2012) Induced Breeding of African Mud Catfish, *Clarias gariepinus* (Burchell 1822), using Different Doses of Normal Saline Diluted Ovaprim. *J Aquacult Res Dev* 3:133 doi:10.4172/2155-9546.1000133
- Orji, R.C.A., Nnadi, C.N., and Onyike, G. (1997). Effect of different salinity levels on the fertilization and hatching of *Heterobranchus bidorsalis*. *NAGA The ICLARM Quarterly* pp. 21-22.
- Sahoo, S.K., Giri S.S., Chandra S. and Sahu A.K., (2007). Spawning performance and egg quality of Asian catfish *Clarias batrachus* (Linn.) at various doses of human chorionic gonadotropin (HCG) injection and latency periods during spawning induction. *Aquaculture*, 266: 289-292.
- Su, B., Perera, D. A., Mu, X., & Dunham, R. A. (2013). Effect of Sodium Chloride on Hatching Rate on Channel Catfish, *Ictalurus punctatus*, Embryos. *Journal of Applied Aquaculture* 25(4): 283–292
- Ukwuani, C.M., Adinde, J.O., Anieke, U.J., Nwankwo, O.G., Ugwuanyi, P.O., Ugwu, M.K., Ajibo, F.E., Aniakor, A.C., and Isani, L.C. (2016). Induced Breeding Of African Catfish (*Clarias gariepinus*) As Influence By Milt Dilution Through Different Levels Of Normal Saline Inclusion *G.J.B.B.*, 5 (3) 340-344 ISSN 2278 – 9103

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Studies of genetic variation and population structure in *Lates niloticus* populations from Lake Kainji and River Benue using Single Sequence Repeats

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Abstract

This study examined the genetic variation between populations of *Lates niloticus* from Lake Kainji and River Benue. DNA was extracted from *Lates* specimens and genotyped on five (5) SSR loci. Allelic variability within and among studied populations showed that the mean number of alleles (A_N) per population was 11.400 ± 0.678 in Lake Kainji and 11.600 ± 0.600 in River Benue. The effective number of alleles (A_E) was 9.00 ± 0.599 and 9.568 ± 0.596 for Lake Kainji and River Benue respectively. Genetic variability showed that observed heterozygosity (H_O) per population was 0.176 ± 0.301 and 0.317 ± 0.335 while expected heterozygosity (H_E) was 0.414 ± 0.306 and 0.588 ± 0.167 . This study affirms the use of SSR DNA markers as tools to quantify the differences that exist among fish stocks.

Key words: Genetic Variation, SSR, *Lates niloticus*

Introduction

Genetic diversity plays a crucial role in the adaptation ability of a population in the face of fluctuating environmental conditions (Makert *et al.*, 2010). However, Genetic markers offer a reliable approach for unveiling the genetic structure both among and within populations (Kajungiro *et al.*, 2019). In a new development, *Lates niloticus* is a very important economic freshwater fish species; as such, the knowledge of population genetic structure and genetic diversity is crucial. *Lates niloticus* (Linnaeus, 1758) is considered as one of the most famous carnivorous freshwater fish in Africa - reaching a maximum length of two meters (2 m) and weighing up to 200 kg (Mohammed, 2012). Undoubtedly, *L. niloticus* being an important economic freshwater fish species has yielded increase in total fisheries and has led to fish related employment (Kitchel and Schindler, 1997). However, the high rate of *L. niloticus* catch and sales by fisher folks especially in Northern Nigeria continuously deplete the biodiversity and genetic variability. Moreover, fish production in most freshwater bodies in Northern Nigeria appears to have been drastically impoverished while the ecosystem seems to be moving towards a new equilibrium due to overfishing, improper fishing methods, habitat disruption and pollution (Oyero, 2001). Hence, this present study investigated the genetic variation and population structure of *Lates niloticus* in Lake Kainji and River Benue using SSR, in order to test the hypothesis of low genetic diversity in the studied populations.

Materials and Methods

Study areas: *L. niloticus* were sampled over a wide geographical range in Kainji Lake on the River Niger (9°50'–1°55' N and 4°23'–4°45' E) and River Benue (7°44' N and 8°31' E). Following animal ethics guidelines, 10 adult specimens (n=10) of *Lates niloticus* (120 kg) were obtained from both Lake Kainji and River Benue.

Sample preservation: Pectoral fin clips of samples were collected and preserved in 80 % ethanol and kept at 4°C in a thermo cool freezer prior to DNA extraction.

DNA extraction: Genomic DNA of *L. niloticus* was isolated using CTAB method. The DNA concentrations of all samples were further measured on spectrophotometer at 260 nm and 280 nm while the genomic purity was determined using the procedure of Edward and Thompson, (1994).

PCR Reaction mix for SSR: The reaction mix was carried out in 20µl final volume containing 60 ng – 80 ng genomic DNA, 0.1 µM of forward and reverse primers, 2 mM MgCl₂, 125 µM of each dNTP and 1 unit of Taq DNA polymerase following the method of Mullis *et al.*, (1986).

Gel Electrophoresis: PCR amplicon electrophoresis was carried out by size fractionation on 1.4 % agarose gel and was done at 100 V for 2 hours. The DNA was visualized and photographed on UV light source (Smithies, 1955).

Data analysis: DNA Sequences from each sample and their banding pattern from the gel was scored for the five SSR primers. Genetic variation parameters were calculated for every population and per locus across both populations using GenAlex 6.1 Soft ware (Peakall and Smouse, 2006). Analysis of molecular variance (AMOVA) was calculated using the methods of Excoffier and Heckel, (2006).

Results

Allelic variability: Measures of allelic variability within populations are presented in Table 1. The mean number of alleles (A_N) per population was 11.400 ± 0.678 in Lake Kainji populations and 11.600 ± 0.600 in River Benue populations. The effective number of alleles (A_E) was 9.00 ± 0.599 and 9.568 ± 0.596 in Lake Kainji and River Benue populations respectively. Shannon information index (I) was 2.307 ± 0.059 and 2.344 ± 0.054 for Lake Kainji and River Benue populations respectively (Table 1).

Genetic Variability: Observed heterozygosity (H_O) per population was 0.176 ± 0.301 and 0.317 ± 0.335 for Lake Kainji and River Benue populations respectively (Table 1) while expected heterozygosity (H_E) was 0.414 ± 0.306 and 0.588 ± 0.167 for Lake Kainji and River Benue populations respectively. Analysis of molecular variance showed that 62 % and 38 % of the total molecular variance was within and among populations respectively (Table 3).

Genetic structure: The coefficient of hierarchical genetic structure (F_{ST}) estimated according to Wright (1978) was 0.236 (Table 2). The overall gene flow (Nm) among populations was 0.806 (Table 2).

Table 1: Genetic variation indices for Single Sequence Repeats

Population	A_N	A_E	I	P_R	H_O	H_E
Lake Kainji	11.400 $\pm$ 0.678	9.000 $\pm$ 0.599	2.307 $\pm$ 0.059	0.000 $\pm$ 0.00	0.523 $\pm$ 0.315	0.715 $\pm$ 0.097
River Benue	11.600 $\pm$ 0.600	9.568 $\pm$ 0.596	2.344 $\pm$ 0.054	0.600 $\pm$ 0.400	0.317 $\pm$ 0.335	0.588 $\pm$ 0.167

A_N = Mean number of alleles, A_E = Effective number of alleles, I = Shannon's Information index, P_R = Private alleles unique to a single population, H_O = Observed Heterozygosity, H_E = Expected Heterozygosity

Table 2: Genetic differentiation

FIS	FIT	FST	Nm
0.4078	0.5479	0.2366	0.8067

F_{IS} = Inbreeding coefficient at population level,
 F_{IT} = inbreeding coefficient at total sample level,
 F_{ST} = Proportion of differentiation
 Nm = Gene flow.

Table 3: Analysis of Molecular Variance

	% Variance
Among Population	38%
Within Population	62%
Total	100%

Table 4: List of SSR primers used

Primer Name	Sequence
UNH 934 F	ACTGCAATGAAATGCTGCTT
UNH 934 R	CCATTCTCAGAGCACAACA
GM 166 F	TGTGAGGCTCTTCTTTTGCT
GM 166 R	AAGAGCGGTGGGTGGAC
GM 385 F	GGTGGGCAGTGTGTGTTTTT
GM 385 R	TTTTCATCCAGGCCTCACTT
UNH 919 F	TGACAGCCTGGCATAATGAG
UNH 919 R	CACTGAGACTGGAAGGCACA
GM 634 F	CTGAAACATGACTGCAGGAG
GM 634 R	CCCGACATTAACTTTCAGCA

Discussion

Understanding population structure, genetic diversity, the patterns and extent of genetic divergence within and between fish populations is important for sustainable aquaculture production and efficient management of wild populations. In this study, the mean number of alleles (A_N) per population was 11.400 and 11.600 for both Lake Kainji and River Benue populations. The results were higher compared to the values obtained in Lake Kainji by Basiita *et al.*, (2018). The effective number of alleles which was high in both populations (9.000 and 9.568) indicates the presence of genetic drift within studied populations. It therefore indicates units of interbreeding individuals which results to enormous variability among populations. The Shannon information index in both populations, which is significantly higher than 1 (2.307 and 2.344) also indicates diversity.

Private alleles were only found in river Benue (0.600 ± 0.400) which signifies an estimated per locus mutation and gene flow. Also, heterozygosity (H_O and H_E) which is used to compare the amount of genetic variation within different populations revealed a higher expected heterozygosity (H_E) value of 0.414 ± 0.306 and 0.588 ± 0.167 and a lower observed heterozygosity (H_O) value of 0.176 ± 0.301 and 0.317 ± 0.335 for Lake Kainji and River Benue populations respectively. This was in correlation with the studies of Basiita *et al.*, (2018) for *Lates* populations but differs from the findings of Gu *et al.*, (2014) and Mireku *et al.*, (2017) who reported average mean levels of 0.3972, 0.4264, 0.6977, 0.6335, 0.6680, and 0.6829, as well as 0.526 and 0.459 respectively.

Lates niloticus in Lake Kainji and River Benue was highly differentiated with significant ($P < 0.000$) F_{ST} of 0.23, showing strong genetic structuring which can be compared to *Lates* populations studied across Africa in the studies of Basiita *et al.*, (2018).

Furthermore, this indicates that on the average, 23.6% of total genetic diversity is present within the populations. This significant F_{ST} value suggests limited dispersal of the species between the two populations of Lake Kainji and River Benue since the result is consistent with findings in other aquatic species (Basiita *et al.*, 2018; Gu *et al.*, 2014 and Mireku *et al.*, 2017), where patterns of isolation by distance have been found to arise from limited dispersal that decreases with increased distance. The overall gene flow (N_m) among populations was 0.806, which gave an estimated average number of migrants between the studied populations per generation. Analysis of variance revealed the existence of higher genetic variation within populations than between populations. This is in correlation with the studies of Kajungiro *et al.*, (2019).

This study showed evidence of reduced genetic diversity in *Lates niloticus* populations as the patterns observed for allelic diversity is consistent with the general hypothesis of loss of genetic diversity which may be due to pressures from heavy fishing activities, climate and ecological pressures as well as the activities on the dam, especially in Lake Kainji. In conclusion, the knowledge of genetic structure and variation revealed in this study among *Lates niloticus* populations in Lake Kainji and River Benue will be useful in forming an artificial and diverse bank for the culturability, breeding, effective management and conservation of the economic species.

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References

- Basiita, R.K., Zenger, K.R., Mwanja, M.T., and Jerry, D.R. (2018) Gene flow and genetic structure in Nile perch, *Lates niloticus*, from African freshwater rivers and lakes. *PLOS ONE* 13(7): e0200001.
- Edwards, K.C., Thompson, C. (1994). A simple and rapid method for the preparation of plant genomic DNA for PCR analysis. *Nucleic Acids Res*, 19:1349.
- Excoffier, L., and Heckel, G. (2006). Computer programs for population genetics data analysis: a survival guide. *Nature Reviews Genetics*, 7: 745–758.
- Gu, D. E., Mu, X. D., Song, H. M., Luo, D., Xu, M., and Luo, J. R. (2014). Genetic diversity of invasive *Oreochromis* spp. (tilapia) populations in Guangdong province of China using microsatellite markers. *Biochem. Syst. Ecol.* 55, 198–204. doi: 10.1016/j.bse.2014.03.035
- Kajungiro, R. A., Palaokostas, C., Pinto, F.A., Lopes, Mmochi, Aviti, J., Mtolera Marten, Houston Ross D., and de Koning Dirk, Jan. (2019). Population Structure and Genetic Diversity of Nile Tilapia (*Oreochromis niloticus*) Strains Cultured in Tanzania. *Frontiers in Genetic.* 10: Pp 1269. DOI=10.3389/fgene.2019.01269. ISSN=1664-8021
- Kitchel, J., and Schindler, D. (1997). The Nile Perch in Lake Victoria: interactions between predation and fisheries. *Ecological Application*, 7(2):653 – 664.
- Linnaeus, C.O. (1758). *Systema naturae per regna tria naturae, secundum classes, ordinus, genera, species, cum characteribus, differentiis, synonymis, locis.* Tomus I. Editio decima, reformata. Impensis Direct. Laurentii Salvii, Holmiae. 824 p. (Ref. 1652).
- Mireku, K. K., Kassam, D., Changadeya, W., Attipoe, F. Y. K., and Adinortey, C. A. (2017). Assessment of genetic variations of Nile Tilapia (*Oreochromis niloticus* L.) in the Volta Lake of Ghana using microsatellite markers. *Afr. J. Biotechnol.* 16, 312–321. doi: 10.5897/AJB2016.15796
- Markert, J. A., Champlin, D. M., Gutjahr-Gobell, R., Grear, J. S., Kuhn, A., and McGreevy, T. J. (2010). Population genetic diversity and fitness in multiple environments. *BMC Evol. Biol.* 10, 205. doi: 10.1186/1471-2148-10-205
- Mohammed O.M. (2012) Classification studies of the Nile perch (*Lates niloticus* Linnaeus, 1758) performed in the Sudan region. *International Journal of Biology, Pharmacy and allied sciences.* IJBPAS, 1(5): 770-779
- Mullis, K., Faloona, F., Saiki, R., Horn, G. and Erlich, H. (1986). Specific enzymatic amplification of DNA in vitro: the polymerase chain reaction. Cold Spring Harbor Symposium. *Quantitative Biology* 51: 263-273.
- Oyero, J.O. (2001). A preliminary investigation into the post harvest losses of fish in Shiroro Lake area. 14th Annual Conference of the Fisheries Society of Nigeria (FISON). Pp. 213-216
- Peakall, R. and Smouse, P.E., (2006). GENALEX 6: Genetic analysis in Excel, Population genetic software for teaching and research. *Molecular Ecology Notes.* 6: 288-295.
- Smithies, O. (1955). Zone electrophoresis in starch gels: group variation variations in the serum proteins of normal human adults. *Journal of Biochemistry*, 4, 61: 629-641; DOI10.1042/BJ0610629
- Wright, S. (1978). *Evolution and the Genetics of Population, Variability Within and Among Natural Populations.* The University of Chicago Press, Chicago. Chapter 9, Pp. 213-216

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Genome-Wide Characterization of Perfect Microsatellites in Nile Tilapia (*Oreochromis niloticus*)

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Abstract

Microsatellites or simple sequence repeats (SSRs) consists a sizable part of genomes and play a crucial role in function of gene and genome organization. The availability of a complete genome sequence for Nile tilapia (*Oreochromis niloticus*) provides the possibility of carrying out genome-wide analysis of microsatellites in this species. I analyzed the abundance and density of perfect SSRs in the Nile tilapia genome and found a total of 252,047 SSRs with 1–6 bp nucleotide motifs. This indicates that about 2.7 % of the Nile tilapia whole genome sequence (927.77 Mb) comprises perfect SSRs, the average length of which was 135.68 bp/Mb. The average frequency and density of perfect SSRs was 271.69 loci/Mb and 5834.46 bp/Mb, respectively. The proportional distribution of the six classes of perfect SSRs in the Nile tilapia genome was not even. Dinucleotide repeats (40.13 %) with a total count of 101,145 and an average length of 26.11 bp seems to be the most abundant SSRs class, while the percentages of mononucleotide, trinucleotide, tetranucleotide, pentanucleotide, and hexanucleotide repeats were 31.88 %, 11.98 %, 11.52 %, 4.22 % and 0.26 %, respectively. Different repeat classes of SSRs varied in their repeat number with the highest being 95. My results suggest that 21 motifs comprised the predominant categories with a frequency above 1 loci/Mb: A, AAC, AAG, AATAG, AATTC, AC, AG, AGAT, AT, ATCT, ATG, ATGG, ATT, ATTT, C, CCT, CTG, CTTT, GT, GTTT.

Keywords: Frequency, Genome, Microsatellite, Nile tilapia, Repeat motif

Introduction

Microsatellites are tandemly repeated DNA sequences, usually referred to as Simple Sequence Repeats (SSRs) or “short tandem repeat” (STR) of about 1–6 bp lengths per unit (Tautz and Renz 1984). Microsatellites are co-dominant in nature, highly polymorphic, easily typed, and Mendelian inherited, all properties which make them ideal genetic marker utilised for biogeography, microevolutionary pedigree analysis, population genetics studies and genome analysis (Anane-Taabeah *et al.*, 2019; Guichoux *et al.*, 2011; Tibihika *et al.*, 2020).

The Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758) is native to north, west and central Africa, adapted to freshwater and brackish water at optimal temperatures between 28°C to 42°C (Trewavas, 1983; Teichert-Coddington *et al.*, 1997). It is the most translocated cichlid fish species across the world for aquaculture due to its economic profitability to farmers; characterised by fast growth rate, early sexual maturity, a high degree of parental care, ability to spawn multiple broods in a season and high fecundity associated with its large body size (Trewavas, 1983; Ojuok *et al.*, 2007). However, its escape from the aquaculture system have resulted in hybridization concerns (Shechonge *et al.*, 2018; Zengeya *et al.*, 2015, 2017).

Tilapia-specific SSR markers have been used by some researchers to study the population and evolution genetics of *Oreochromis niloticus* (Anane-Taabeah *et al.*, 2019; Bezault *et al.*, 2011; Bradbeer *et al.*, 2019; Tibihika *et al.*, 2018; 2020; Fuerst *et al.*, 2001; Tesfaye *et al.*, 2021; Wasonga *et al.*, 2017). Carleton *et al.* (2002) found (CA)_n microsatellite in *Oreochromis niloticus* with the number of repeats ranging from four to 45 with an average of 19. These studies contributed enormous useful information for the assessment, management and protection of *O. niloticus* as a genetic resource.

The availability of complete *O. niloticus* genome sequence has made it possible to carry out genome-wide analysis (Brawand *et al.*, 2014). However, there seems to be no reports on the abundance and density of microsatellites (1–6 bp) repeats in the *O. niloticus* genome. I screened the entire *O. niloticus* genome sequence to study the distribution and density of perfect SSRs, in order to facilitate the understanding of structure of the *O. niloticus* genome, and to build up a foundation for the isolation and identification of more *O. niloticus*-specific SSRs.

Materials and methods

The complete *Oreochromis niloticus* genome sequence (GCA_000188235.2) from Broad Institute, USA, with a total length of 927,696,114 bp was downloaded (Brawand *et al.*, 2014) in FASTA file format to generate SSRs data. MSDB 2.4.3 (Microsatellite Search and Building Database) (<http://msdb.biosv.com/>) (Lianming *et al.*, 2012) was used to scan the entire *O. niloticus* genome for abundance and density of perfect SSRs, using the “perfect” search mode with “all motifs” in the type of motif column selected. I identified six classes of microsatellites: mono-, di-, tri-, tetra-, penta- and hexa-nucleotide SSR motifs at a minimum repeat number of 12, 7, 5, 4, 4 and 4, respectively. The flanking sequence length was constrained to 200 bp. The statistics of the Microsatellite were selected using the “whole” mode, indicating that the program will generate one statistical Excel file for all sequence files as a whole. For statistical analysis, repeats with unit patterns being complements were considered as one type. For example, ATTT denotes AAAT in different reading frames or on the complementary strand. The software SPSS 19.0 was used to perform the data analysis and mapping. To facilitate the comparison among different repeat categories, the relative frequency, (SSR number per Mb of the sequence analyzed), and the relative density, [SSR length (in bp) per Mb of the sequence analyzed] were evaluated.

Results

Frequency and density of six classes of microsatellites

A total of 252,047 SSRs were identified in the *O. niloticus* genome assembly after scanning the genome sequence for six classes of SSRs (Table 1). The total and average lengths were 541,2605 bp and 135.68, respectively. The relative frequency and density were 271.69 loci/Mb and 5834.46 bp/Mb, respectively. About 2.7 % of the *O. niloticus* whole genome (927.77 Mb) was occupied by the perfect SSRs. The counts, length, frequency, density and percentages of the six classes of perfect SSRs are summarized in Table 1. Dinucleotides were the most abundant type, with the highest relative frequency (109.03 loci/Mb) and density (2846.889 bp/Mb), accounting for 40.13 % of all SSRs, followed by mono-nucleotides (31.88 %), tri-nucleotides (11.98 %), tetra-nucleotides (11.52 %), penta-nucleotides (4.22 %), and hexa-nucleotides (0.26 %).

Abundance and repeat numbers for different microsatellite categories

Mononucleotide repeats

The predominant mononucleotide repeat category was Poly (A) [or poly (T)], with 74,905 loci accounting for 93.2 % of the mononucleotide SSRs. The total length, frequency and density of poly (A) was 571,450 Mb, 40.38 loci/Mb and 615.99 bp/Mb, respectively, and the average length was 15.25 bp (Table 2). However, poly (C) [or poly (G)] accounted for only 6.78 % of the total mononucleotide SSRs which was far less abundant than poly (A) [or poly (T)]. The abundance of poly (C) was also lower (namely 2.95 loci/Mb and 39.56 bp/Mb, respectively). The repeat numbers of mononucleotide repeats ranged from 12 to 95 times. The predominant repeat times ranged from 12 to 31, which numbered 79,701 accounting for 99.17 % of the total count of mononucleotide SSRs (Fig. 1A).

Dinucleotide repeats

Dinucleotide repeats the most abundant SSRs class include AC, AT, AG, CT and GT categories. Results showed that the frequencies of GT and AC were highest (41.29 loci/Mb and 40.68 loci/Mb, respectively). AT, AG and CT had middle frequencies of 13.39, 6.85 and 6.66 loci/Mb respectively (Table 2). These categories of SSRs numbered 101,008 and accounted for 99.86 % of the total number of dinucleotide repeats. The GC repeat had the lowest frequency of 0.15 loci/Mb and numbered 137. The repeat times of dinucleotide repeats ranged from 7 to 48 times. However, the predominate repeat times ranged from 7 to 30 which numbered 100,058 and accounted for 99 % of the total count of dinucleotide SSRs (Fig. 1B).

Trinucleotide repeats

Analysis of all trimer repeats including AAC, AAG, AAT, AGC, AGG, ATC, ATG, ATT, CCT, CTG, CTT, and GTT showed that ATT and AAT had the highest frequency of 6.32 and 6.32 loci/Mb. Two categories of AAC and GTT had the middle frequencies that were 2.31 loci/Mb and 2.24 loci/Mb (Table 2), respectively. The lower frequencies ranged from 1.27 to 1.94 loci/Mb. The repeat times of trinucleotide SSRs ranged between 5 and 32 times. But 5–19 repeat times were predominant and numbered 30,067 and accounted for 99.5 % of the total count of trinucleotide SSRs (Fig. 1C).

Tetranucleotide repeats

Analysis of frequencies and densities of each tetrameric repeat revealed that 10 categories were predominant across the genome, and had frequencies of more than 1 loci/Mb (Table 2). The frequencies of AAAT and ATTT were highest with 3.95 loci/Mb and 3.38 loci/Mb while ATGG, ATCC, GTTT and AAAC were at middle range of 2.86 loci/Mb, 2.76 loci/Mb, 2.71 loci/Mb and 2.57 loci/Mb respectively. The frequencies of the lower tetrameric repeats ATCT, AGAT, CTTT and AAAG were 1.43 loci/Mb, 1.35 loci/Mb, 1.07 loci/Mb and 1.01 loci/Mb. The SSRs range of tetranucleotide repeat times were between 4 and 24 times but 4–10 repeat times were predominant, and numbered 26,960 and accounted for 93 % of the total count of trinucleotide SSRs (Fig. 1D).

Pentanucleotide repeats

In pentanucleotide repeats categories, AATTC, AATTG and AATAG had a higher frequency of 1.37 loci/Mb, 1.25 loci/Mb and 1.04 loci/Mb, and density of 32.62 bp/Mb, 29.73 bp/Mb and 29.85 bp/Mb (Table 2), respectively. The frequencies of remainder categories were <0.63 loci/Mb. The repeat times of pentanucleotide SSRs ranged between 4 and 20 times. However, repeats ranging between 4 and 8 times were predominant, and numbered 9,796 and accounted for 92 % of the total count of pentanucleotide SSRs (Fig. 1E).

Hexanucleotide repeats

The frequencies of all hexanucleotide repeat categories ranged between 0.03 loci/Mb and 0.00 loci/Mb and were lower than that of above five types of repeats. The repeat times of hexanucleotide SSRs ranged between 4 and 15 times. Moreover, the predominate repeat times ranged between 4 and 6, and numbered 658 which is 98.80 % of the total hexanucleotide SSRs count (Fig. 1F).

Table 1 Count, length, frequency, density and percentage of six types of perfect microsatellites in *O. niloticus* genome sequence

Nucleotide	Total Counts	Total Length(bp)	Average Length(bp)	Frequency(loci/Mb)	Density(bp/Mb)	%
mononucleotide	80361	1216211	15.13	86.62	1311.002	31.88
dinucleotide	101145	2641048	26.11	109.03	2846.889	40.13
trinucleotide	30205	595320	19.71	32.56	641.719	11.98
tetranucleotide	29038	659180	22.70	31.3	710.556	11.52
pentanucleotide	10632	283980	26.71	11.46	306.113	4.22
hexanucleotide	666	16866	25.32	0.72	18.181	0.26
Total	252,047	5,412,605	135.68	271.69	5834.46	

Table 2 Count, length, frequency and density percentage of different categories of SSRs (frequency above 1 loci/Mb in increasing order) in Nile tilapia genome sequence

Motif	Total Counts	Total Length(bp)	Average Length(bp)	Frequency(loci/Mb)	Density(bp/Mb)
A	37464	571450	15,25	40,38	615,99
T	37441	571251	15,26	40,36	615,77
C	2740	36698	13,39	2,95	39,56
G	2716	36812	13,55	2,93	39,68
AC	37742	1058712	28,05	40,68	1141,23
GT	38309	1078568	28,15	41,29	1162,63
AT	12419	258786	20,84	13,39	278,96
AG	6356	123432	19,42	6,85	133,05
CT	6182	119452	19,32	6,66	128,76
ATT	5862	129342	22,06	6,32	139,42
AAT	5798	129420	22,32	6,25	139,51
AAC	2146	39336	18,33	2,31	42,4
GTT	2081	38433	18,47	2,24	41,43
CCT	1799	31155	17,32	1,94	33,58
AGG	1793	31095	17,34	1,93	33,52
ATG	1592	31059	19,51	1,72	33,48
ATC	1454	28362	19,51	1,57	30,57
AAG	1578	28413	18,01	1,7	30,63
CTT	1548	28131	18,17	1,67	30,32
CTG	1216	21006	17,27	1,31	22,64
AGC	1182	20394	17,25	1,27	21,98
ATTT	3665	64996	17,73	3,95	70,06
AAAT	3140	56096	17,86	3,38	60,47
ATGG	2649	64376	24,3	2,86	69,39
ATCC	2563	61676	24,06	2,76	66,48
GTTT	2510	48980	19,51	2,71	52,8
AAAC	2388	46284	19,38	2,57	49,89
ATCT	1329	59380	44,68	1,43	64,01
AGAT	1249	57560	46,08	1,35	62,05
CTTT	988	22568	22,84	1,07	24,33
AAAG	934	21892	23,44	1,01	23,6
AATTC	1270	30265	23,83	1,37	32,62
AATTG	1163	27580	23,71	1,25	29,73
AATAG	962	27690	28,78	1,04	29,85

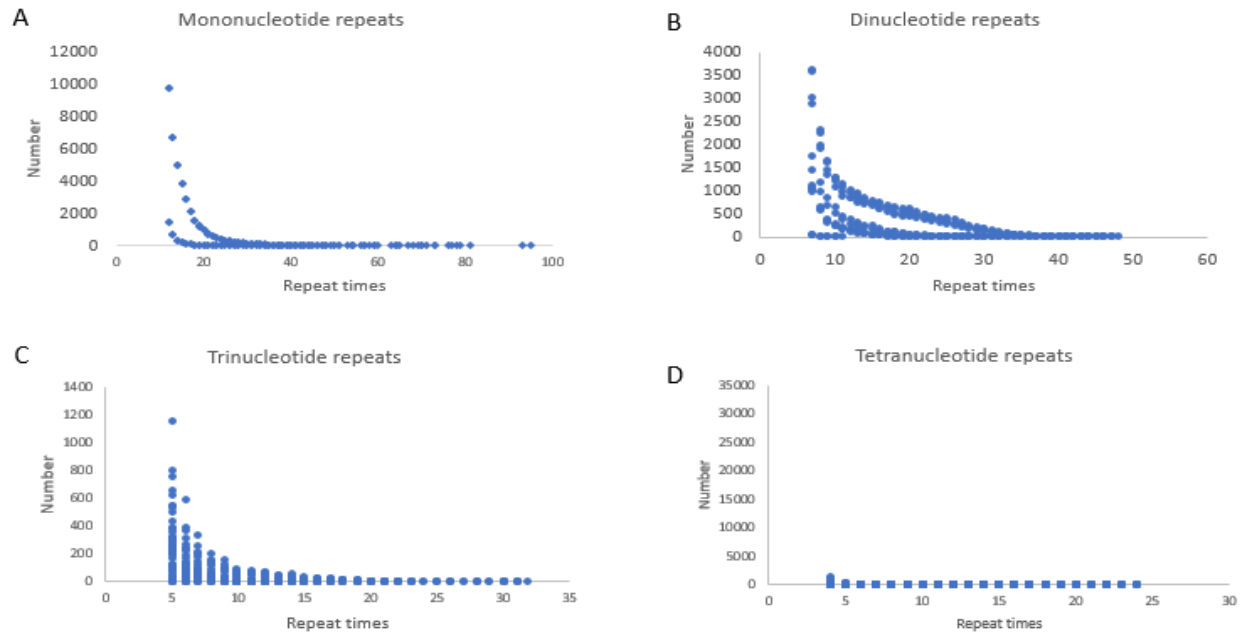


Fig. 1 Repeat times of different types of SSRs in Nile tilapia genome.

Discussion

Presently, a scan of SSR for the entire *Oreochromis niloticus* genome sequence applying bioinformatics methodology has not been reported. We first examined the abundance of perfect SSRs made up of 1–6 bp motifs in *O. niloticus* genomic sequence. In this research, about 2.7 % of the *O. niloticus* genome comprised perfect SSRs from mono- to hexa-nucleotide repeats. This percentage is similar to previous reports on the genomes of human (3 %) (Subramanian *et al.*, 2003), mosquitoes (2.14 %) (Yu *et al.*, 2005) and mouse (2.85 %) (Tong *et al.*, 2006) but higher than that of yak (0.47 %) (Zhijie, 2015), cattle (0.48 %) (Qi *et al.*, 2013), sheep (0.48 %) (Qi *et al.*, 2013) and chicken (0.49 %) (Huang *et al.*, 2012). The different bioinformatics software tools applied in various studies for SSRs identification, the search criteria variation and the database size could account for the percentage differences.

There was an uneven proportional distribution of the six classes of perfect SSRs in the *O. niloticus* genome. Dinucleotide repeats, accounting for the largest proportion (40.13 %) in six types of SSRs, had the highest frequency (109.03 loci/Mb) and maximum density (2846.889 bp/Mb), followed by mononucleotide, trinucleotide, tetranucleotide, pentanucleotide, and hexanucleotide repeats. Hexanucleotide repeats had the lowest frequency (0.72 loci/Mb) and minimum density (18.181 bp/Mb) (Table 1). This pattern is similar to findings in cattle, chicken, human, sheep and yak genomes, (Subramanian *et al.*, 2003; Huang *et al.*, 2012; Qi *et al.*, 2013; Zhijie, 2015), but is different from that of drosophila, mosquito, mouse, silkworm, and zebra fish (Katti *et al.*, 2001; Li *et al.*, 2004; Yu *et al.*, 2005; Tong *et al.*, 2006; Coe, T. *et al.*, 2009). Selection for or against mono-, di-, trimers, tetra-, penta- and hexamers repeats could account for this difference in abundance.

This current investigation showed that the density and number of some categories of repeat are more than others within each type of repeats. For instance, the mononucleotide repeats, Poly(A) [or Poly (T)] showed a big over-representation, accounting for 93.2 % of the total number of mononucleotide SSRs categories. Likewise, in the other five classes of SSRs, thirteen categories including GT, AC, AAT, ATT, AAAT, ATTT, ATGG, ATCC, GTTT, AAAC, AATTC, AATTG and AATAG in *O. niloticus* genome were the predominant repeats, with a normal frequency higher than 1.00 loci/Mb (Table 2). The large amounts of repeats might be influenced by their secondary structures and the effect on DNA replication. Possibly during SSR evolution a mutation occurred at the poly (A) stretches present in the genome to produce the A-rich repeats. Furthermore, there are different repeat times for the different categories of SSRs. For instance, the mononucleotide SSRs repeat times ranged mainly between 12 and 31, the dinucleotide SSRs ranged between 7 and 30 times, trinucleotide SSRs ranged between 5 and 19 times, and the repeats ranges for tetranucleotide, pentanucleotide and hexanucleotide SSRs were between 4–10, 4–8, and 4–6 (Fig. 1), respectively. of this study is consistent with findings that Nucleotide sequences with higher AT content has been

shown to possess more SSRs than those of higher GC content (Schlotterer 1998). This is consistent with our observation of higher AT-rich content of SSRs present in *O. niloticus* genome.

Studies should be emphasised on, the difference in abundance of different classes of SSRs in coding and non-coding regions of in *O. niloticus* genome (i.e. exon, intron and intergenic regions). Moreover, Some studies showed that SSRs play an important role in the structure and function of the genome and may be associated with some diseases (Hefferon *et al.*, 2004; Campregher *et al.*, 2010).

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References

- Anane-Taabeah, G., Frimpong, E. A., & Hallerman, E. (2019). Aquaculture-mediated invasion of the genetically improved farmed tilapia (GIFT) into the lower volta basin of Ghana. *Diversity*, 11, 188.
- Bezault, E., Balaesque, P., Toguyeni, A., Fermon, Y., Araki, H., Baroiller, J. F., & Rognon, X. (2011). Spatial and temporal variation in population genetic structure of wild Nile tilapia (*Oreochromis niloticus*) across Africa. *BMC Genetics*, 12, 102.
- Bradbeer, S. J., Harrington, J., Watson, H., Warraich, A., Shechonge, S., Smith, A., Tamatamah, R., Ngatunga, B. P., Turner, G. F., & Genner, M. J. (2019). Limited hybridization between introduced and critically endangered indigenous tilapia fishes in northern Tanzania. *Hydrobiologia*, 832, 257-268. <https://doi.org/10.1007/s10750-018-3572-5>.
- Brawand, D., Wagner, C. E., Li, Y. I., ... Di Palma, F. (2014). The genomic substrate for adaptive radiation in African cichlid fish. *Nature*, 513-375. <https://doi.org/10.1038/nature13726>
- Campregher, C., Scharl, T., Nemeth, M., Honeder, C., Jascur, T., Boland, C.R., & Gasche, C. (2010) The nucleotide composition of microsatellites impacts both replication fidelity and mismatch repair in human colorectal cells. *Human Molecular Genetics*, 19, 2648–2657.
- Carleton, K. L., Streelman, J. T., Lee, B.-Y., Garnhart, N., Kidd, M., & Kocher, T. D. (2002). Rapid isolation of CA microsatellites from the tilapia genome. *Animal Genetics*, 33(2), 140–144.
- Coe, T. S., Hamilton, P. B., Griffiths, A. M., Hodgson, D. J., Wahab, M. A., & Tyler, C. R. (2009). Genetic variation in strains of zebrafish (*Danio rerio*) and the implications for ecotoxicology studies. *Ecotoxicology* (London, England) 18, 144–150.
- Fuerst, P., Mwanja, W., & Kaufman, L. (2000). The genetic history of the introduced Nile tilapia of Lake Victoria (Uganda–E. Africa): the population structure of *Oreochromis niloticus* (Pisces: Cichlidae) revealed by DNA microsatellite markers. In: *Tilapia Aquaculture in the 21st Century Proceedings from the Fifth International Symposium on Tilapia in Aquaculture; 2000*.
- Guichoux, E., Lagache, L., Wagner, S., Chaumeil, P., Le'ger, P., Lepais, O., Lepoittevin, C., Malausa, T., Revardel, E., Salin, F., & Petit, R. J. (2011). Current trends in microsatellite genotyping. *Molecular Ecology Resources*, 11, 591–611.
- Hefferon, T.W., Groman, J. D., Yurk, C. E., & Cutting, G. R. (2004). A variable dinucleotide repeat in the CFTR gene contributes to phenotype diversity by forming RNA secondary structures that alter splicing. *Proceedings of the National Academy of Sciences of the United States of America*, 101, 3504–3509.
- Huang, J., Du, L. M., Li, Y. Z., Li, W. J., Zhang, X.Y., & Yue, B. S. (2012). Distribution regularities of microsatellites in the *Gallus gallus* genome. *Sichuan Journal of Zoology*, 31, 358–363 (in Chinese with English abstract).
- Katti, M. V., Ranjekar, P. K., Gupta, V. S. (2001). Differential distribution of simple sequence repeats in eukaryotic genome sequences. *Molecular Biology of Evolution*, 18, 1161–1167.
- Li, B., Xia, Q. Y., Lu, C., Zhou, Z.Y., & Xiang, Z. H. (2004) Analysis on frequency and density of microsatellites in coding sequence of several eukaryotic genomes. *Genomics, Proteomics Bioinformatics*, 2, 24–31.
- Lianming, D., Yuzhi, L., Xiuyue, Z., & Bisong, Y. (2012). MSDB: A user-friendly program for reporting distribution and building databases of microsatellites from genome sequences. *Journal of Heredity*, 104(1), 154–157 doi:10.1093/jhered/ess082 [Downloaded May 4, 2017]
- Ojuok, J. E., Njiru, M., Ntiba, M. J., & Mavuti, K. M. (2007). The effect of overfishing on the life-history strategies of Nile tilapia, *Oreochromis niloticus* (L.) in the Nyanza Gulf of Lake Victoria, Kenya. *Aquatic Ecosystem Health & Management*, 10, 443-448.

- Qi, W. H., Jiang, X. M., Xiao, G. S., Huang, X. Y., & Du, L. M. (2013). Seeking and bioinformatics analysis of microsatellite sequence in the genomes of cow and sheep. *Acta Veterinaria et Zootechnica Sinica*, 44,1724–1733 (in chinese with english abstract)
- Schlotterer, C. (1998). Genome evolution: are microsatellites really simple sequences? *Current Biology*, 8,132–134
- Shechonge, A., Ngatunga, B. P., Tamatamah, R., Bradbeer, S. J., Harrington, J., Ford, A. G. P., Turner, G. F., & Genner, M. J. (2018). Losing cichlid fish biodiversity: genetic and morphological homogenization of tilapia following colonization by introduced species. *Conservation Genetics*, 19, 1199–1299.
- Subramanian, S., Mishra, R. K., & Singh, L. (2003). Genome-wide analysis of microsatellite repeats in humans: their abundance and density in specific genomic regions. *Genome Biology*, 4, R13.
- Tautz, D., & Renz, M. (1984). Simple sequences are ubiquitous repetitive components of eukaryotic genomes. *Nucleic Acids Research*, 12, 4127–4138.
- Teichert-Coddington, D. R., Popma, T. J., & Lovshin, L. L. (1997). Attributes of tropical pond-cultured fish, pgs 183-198. In: Enga H. S. & Boyd, C. E.(eds.), *Dynamics of pond Aquaculture*. CRC Press, USA: Boca Raton, Florida.
- Tesfaye, G., Curto, M., Meulenbroek, P., Englmaier, G. K., Tibihika, P. D., Alemayehu, E., Getahun, A., & Meimberg, H. (2021). Genetic diversity of Nile tilapia (*Oreochromis niloticus*) populations in Ethiopia: insights from nuclear DNA microsatellites and implications for conservation. *BMC Ecology and Evolution*, 21, 113. <https://doi.org/10.1186/s12862-021-01829-2>.
- Tibihika, P. D., Curto, M., Alemayehu, E., Waidbacher, H., Masembe, C., Akoll, P., & Meimberg, H. (2020). Molecular genetic diversity and differentiation of Nile tilapia (*Oreochromis niloticus*, L. 1758) in east African natural and stocked populations. *BMC Evolutionary Biology*, 20, 16. <https://doi.org/10.1186/s12862-020-1583-0>.
- Tibihika, P. D., Curto, M., Dornstaeder-Schrammel, E., Winter, S., Alemayehu, E., Waidbacher, H., & Meimberg, H. (2018). Application of microsatellite genotyping by sequencing (SSR-GBS) to measure genetic diversity of the East African *Oreochromis niloticus*. *Conservation Genetics*, 20, 357–372. <https://doi.org/10.1007/s10592-018-1136-x>
- Trewavas, E. (1983). Tilapiine fishes of the genera *Sarotherodon*, *Oreochromis* and *Danakilia* (Vol 9, p. 1-583). London, UK: British Museum (Natural History). <https://doi.org/10.5962/bhl.title.123198>
- Tong, X. L., Dai, F. Y, Li, B., Yu, Q. Y., Xia, Q. Y.,& Lu, C. (2006). Microsatellite repeats in mouse: abundance, distribution and density. *Current Zoology*, 52,138–152.
- Yu, Q.Y., Li, B., Li, G. R., Fang, S. M., Yan, H., Tong, X. L., Qian, J. F., Xia, Q. Y., & Lu, C. (2005) Abundance and distribution of microsatellite in the entire mosquito. *Prog Biochem Biophys*, 32, 435–441.
- Wasonga, A. G., Daniel, W. A., & Brian, O. (2017). Interspecific hybridization of Tilapiines in Lake Victoria, Kenya. *Journal of Fisheries Livestock Production*, 5, 235 doi: 10.4172/2332-2608.1000235.
- Zengeya, T. A., Booth, A. J., & Chimimba, C. T. (2015). Broad Niche Overlap between Invasive Nile Tilapia *Oreochromis niloticus* and Indigenous Congenerics in southern Africa: Should We be Concerned?*Entropy*, 17, 4959 – 4973.
- Zengeya, T., Ivey, P., Woodford, D. J., Weyl, O., Novoa, A., Shackleton, R., Richardson, D., & Van Wilgen, R. (2017). "Managing conflict-generating invasive species in South Africa: Challenges and trade-offs", *Bothalia*, 47, no. 2. <http://dx.doi.org/10.4102/abc.v47i2.2160>
- Zhijie, Ma (2015). Genome-wide characterization of perfect microsatellites in yak (*Bos grunniens*). *Genetica*, 143, 515–520. DOI 10.1007/s10709-015-9849-y.

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Breeding Performance of Wild Strains of *Heterobranchus bidorsalis***Megbowon, I.**

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Abstract

A study was conducted to evaluate the breeding performance of wild strains of *Heterobranchus bidorsalis* from different water bodies in Nigeria. The breeding was conducted following standard procedure and the progenies obtained were fed for 30 days in a closed door hatchery system. The strain of *Heterobranchus bidorsalis* from North-West, Nigeria had the highest percentage fertilization, hatchability and survival (83.3 ± 7.7 , 76.9 ± 6.6 and 59.8 ± 9.1) respectively. This was followed by North-East which had 78.2 ± 6.1 and 69.9 ± 10.8 for fertilization and hatchability respectively. However, the survival of this strain was ranked among the least with 43.9 ± 5.6 survival after 30 days of rearing. Domesticated strains had the least of these values 61.8 ± 8.9 and 50.1 ± 8.3 for fertilization and hatchability. The strain from (South-south) Delta state when reared for 60 days showed best growth performance (1.8g average weight) and highest number of shooters (21) while the strain from Kebbi (North-west) gave the least growth (1.05 ± 0.12 g), least number of shooters (6) and lowest standard deviation which implied more uniform offspring. Other strains from Anambra and Oyo also performed well but Kebbi strain had better survival. Collection made from these natural populations (Delta, Anambra and Oyo) when bred with Kebbi strain of high survival has the potential of increasing the production of this species, more importantly, in the Niger Delta where the species is preferred to other species for culture.

Key Words: Breeding, Wild Strains, *Heterobranchus bidorsalis*

Introduction

In Nigeria, like other parts of the world, the catfish species of the family Clariidae have gained much prominence. The species are very popular with fish farmers and consumers alike and as such command a very good commercial value in the markets. The Clariid catfishes exhibit many qualities, which make them suitable for culture. These include ability to withstand handling stress, disease resistance, high yield potential, high fecundity as well as high palatability. (Nwadukwe, 1993). In addition, the Clariid fishes have the ability to grow on a wide range of natural and low cost artificial foods, can withstand low oxygen and pH levels. *Heterobranchus* belongs to this family, Clariidae. *Heterobranchus* species are among the widely accepted and cultured fish species in Nigeria, particularly in the Niger Delta region. Its commercial value is based on fast growth rate (2.8g/day), high fecundity (120,000 eggs/kg of body weight) and continuous reproduction throughout the year after maturity as reported by Otema *et al* (1996).

The scarcity of high quality fish seeds (fingerlings) is one of the major constraints to the rapid development of aquaculture in Nigeria. Several authors have carried out studies on genetic improvement and induced breeding of *Heterobranchus longifilis* (Nwadukwe; 1993, Aluko 1999; Aguigwo and Inyang, 1992, Dada and Olarewaju, 1996, Ovie *et al* 1997). Legendre *et al.* (1992) reported that *Heterobranchus species* had a growth rate twice that of *Clarias gariepinus*. Nigeria accounted for about ninety percent of the catfish supply in Sub-Saharan Africa in 2000 (FAO, 2004). The continuous growth of aquaculture is hinged on the production of fish seeds with high fertilization and survival rates, high feed conversion efficiency, and high growth rate among other factors (Adebayo and Popoola, 2008). This study was conducted to evaluate the breeding performance of wild strains of the fish from different water bodies in Nigeria.

Materials and Methods

Experimental fish: The experimental fish were obtained from natural population in Nigerian waters namely; North-East (Adamawa), North-West (Kebbi), North-Central (Kogi), South-west (Oyo), South-South (Delta), South-East (Anambra) and the control used the domesticated strain cultured by fish farmers in Lagos. The strains were transferred to the Biotechnology Department of Nigerian Institute for Oceanography and Marine Research, Victoria Island, Lagos, where they were acclimatized and fed with coppen feed for gonadal development and maturation.

Induced spawning and stripping

Selected gravid broodstock were kept separately in different tanks without feeding for 15 hours. They were then injected with 0.6 ml Ovaprim® (Syndel, Canada) per kg live weight (Oyeleye and Omitogun, 2007). The injected females were then left for 10-12 hours (latency period) to ensure high hatching rates and low proportion of deformed larvae (Hogendoorn, 1979).

Fertility and hatchability evaluation

The fish were stripped following standard procedure. After stripping of the induced female broodstock, the eggs were weighed in grams. The mixture of eggs and milt was stirred gently for one minute to allow contact and adequate fertilization. The eggs were distributed and incubated in a netted basket suspended in a hatching trough (50cm x 35cm x 30cm).

The percentage fertility and hatchability were determined subjectively after 12 hours of fertilization by identifying the healthy developing eggs which were transparent brownish green in colour while the dead whitish eggs were also estimated:

$$\% \text{ Fertilization} = \frac{(\text{Number of fertilized eggs} \times 100\%)}{\text{Number of Extruded eggs}}$$

$$\% \text{ Hatchability} = \frac{\text{Total number of fertilized eggs} - \text{Total no. of unfertilized eggs}}{\text{Total number of fertilized eggs}} \times 100\%$$

$$\% \text{ Survival} = \frac{\text{Total number of larvae} - \text{No. of dead larvae}}{\text{Total number of larvae}} \times 100\%$$

The data collected on the parameters were subjected to standard statistical analysis. The data collected were analyzed using analysis of variance (ANOVA) to find a level of significance at $p < 0.05$.

Results

The results showed that the strain of *H. bidorsalis* from North-West (Kebbi) had the highest value for percentage fertilization, hatchability and survival (83.3 ± 7.7 , 76.9 ± 6.6 and 59.8 ± 9.1) respectively. This was followed by North-East which had 78.2 ± 6.1 and 69.9 ± 10.8 for fertilization and hatchability respectively. However, the survival rate was the least with 43.9 ± 5.6 survival after 30 days of rearing. Domesticated strains had the lowest values of 61.8 ± 8.9 and 50.1 ± 8.3 for fertilization and hatchability respectively (Table 1). When reared for 30 days, the survival was higher than values obtained for North-central and South-South strains. When this was reared for 60 days, the strain from (South-south) Delta state showed best growth performance (1.8g average weight) and highest number of shooters (21) while the strain from Kebbi gave the least growth ($1.05g \pm 0.12$) and least number of shooters (6). This was closely followed by the domesticated strain (1.72g average weight) (Table 2). The lowest standard deviation in North-West (Kebbi) strain implied more uniform offspring.

Table1: Breeding Performance Of *Heterobranchus Bidorsalis* From 6 Geo-Political Zones Of Nigeria

LOCATION	WEIGHT OF FEMALE (g)	WEIGHT OF EGG (g)	% FERTILIZATION	% HATCHABILITY	% SURVIVAL (30 DAYS)
North Central	3,200.5±162.1	102.21±28.3	73.1±6.0	61.8±7.9	39.4±4.8
North-East	5,630.2±416.8	139.21±19.7	78.2±6.1	69.9±10.8	43.9±5.6
North-West	4,120.8±318.2	123.79±9.4	83.3±7.7	76.9±6.6	59.8±9.1
South-West	5,604.1±608.0	119.9±9.1a	69.9±9.3	62.4±7.8	44.9±3.1
South-East	5,231.1±410.5	150.90±18.8	70.3±9.3	59.7±8.2	48.7±8.9
South-South	5,219.5±703.1	138.6±18.4	62.7±8.3	56.5±11.2	40.9±8.1
Domesticated	3,462.2±523.1	150.9±18.2	61.8±8.9	50.1±8.3	41.2±2.6

Table 2: Growth Performance Of *Heterobranchus Bidorsalis* Fry Raised Over 30 Days In Plastic Tanks

LOCATION	COORDINATE	MAX. WT OF FISH (g)	MIN. WT OF FISH (g)	AVE. WT. OF FISH (g)	STD. DEVIATION	AV. NO. OF SHOOTERS
North – Central (Kogi)	Lokoja (N6 ⁰ 49.02 ¹ , E8 ⁰ 44.1 ⁰) Sakin Noma (N8 ⁰ 12.13 ¹ E6 ⁰ 24.2 ¹)	4.56	0.36	1.32	0.57	13
North-East (Adamawa)	Kiri Lake (N09 ⁰ 61.2 ¹ E12 ⁰ 28.5 ¹) Gerio Lake (N09 ⁰ 12.8 ⁰ E 12 ⁰ 28.6 ¹)	4.70	0.31	1.22	0.45	10
North-West (Kebbi)	Argungun (N 12 ⁰ 44.6 ¹ ; E004 ⁰ 31.31 ¹) River Niger (N11 ⁰ 41.2 ¹ ; E003 ⁰ 37.3 ¹)	3.85	0.26	1.05	0.12	6
South-West (Oyo)	Eleyele Lake (N07 ⁰ 26.2 ¹ E 03 ⁰ 54.2 ¹) Asejire Lake (N07 ⁰ 23.5 ¹ E03 ⁰ 55.0 ¹)	5.01	0.51	1.36	0.14	16
South-East (Anambra)	Otuocha (N06 ⁰ 20.2 ¹ 006 ⁰ 50.3 ¹) Igbariam (N06 ⁰ 23.5 ¹ 006 56.3 ¹)	5.45	0.48	1.41	0.38	13
South-South (Delta)	Umuochi/Ona River (N06 ⁰ 16.1 ¹ E06 ⁰ 42.5 ¹) River Ethiope (N05 ⁰ 54.4 ¹ E05 ⁰ 40.4 ¹)	5.94	0.52	1.81	0.24	21
Domesticated Strain	Lagos	4.53	0.48	1.32	0.51	12

Discussion

Groblar *et al* (1992) and Teugels *et al.* (1992) reported that broodstock selection in the African catfish has largely been through a disjointed, isolated and occasional effort unlike in the case of the American catfish *Ictalurus punctatus*. Fertilization, hatching and early larvae survival are very important for successful aquaculture of the African catfishes. From the present study conducted on these natural populations of *H. bidorsalis*, the strain of *H. bidorsalis* from North–West (Kebbi) performed better than the other strains in terms of fertilization, hatchability and survival. However, growth rate was poor. The breeding indices (fertilization, hatchability and survival) were next in Anambra and Oyo strains. This implied that there was variation in breeding of the various strains. This was in agreement with Van der Waal (1998) who reported that African catfish exhibits considerable growth variation both under aquaculture and in the wild. According to the author, the causes of such variation were not clear, although it has been suggested that inherent differences in feeding behaviour may contribute to this variation (Adeyemo *et al.*, 1994). From this study, such difference may largely be due to the genetic constitution of the different strains of the fish. If the fast-growing strains from Oyo, Anambra and Delta are selectively bred over generations and the gene pool of these are combined with Kebbi strain with higher survival, it may lead to production of broodstock with better quality rather than relying on the domesticated strain which is presently suffering from inbreeding depression. Collection made from these natural populations, with several selective generations of breeding, has the potential of

increasing the production of this species, more importantly, in the Niger Delta where it is preferred to other species for culture. It is important to recognize the fact that differences from breeding history, fish age and water quality parameters can influence hatching rates. Variations in seasons can also bring about differences in hatching rates, as observed by de Graaf *et al* (1995). It was not possible in the present study to state the age or breeding history since broodstock were obtained from the wild. In as much as fecundity does not drop, hatching and survival rates of larvae remain the key to viable and economically beneficial production of catfish fry and fingerlings

References

- Adebayo, O.T. and O.M. Popoola, (2008). Comparative evaluation of efficacy and cost of synthetic and nonsynthetic hormones for artificial breeding of African catfish (*Clarias gariepinus* Burchell, 1822). *J. Fish. Aquat. Sci.*, 3(1): 66-71.
- Adeyemo, A. A., Oladosu, G. A. and Ayinla, A. O. (1994). Growth and Survival of fry of African catfish species, *Clarias ganepnius* Burchell, *Heterobranchus bidorsalis* Geoffery and hetero clarias reared on *Monia dubia* incomparisn with other first feed sources Aquaculture 119: pp 41 45.
- Aguigwo, J. N. and Inyang, N. M. (1992). Ovulation in *Clarias albopunctatus* (Nichols and Lamote) and *Heterobranchus longifilis* (Cuvier and valenciennes) using *clamiphene citrate*: A publication by Journal of Aquatic Sciences. pp 1 6.
- Aluko, P. O. (1999). Induction of tripoidy in *Heterobranchus clarias* hybrids: (Valencies 1840). Proceedings of the 12th Annual Conference of Biotechnology Society of Nigeria. pp 73 75.
- Dada, A.A. and Olarewaju, O. (1996). Comparative growth and survival of catfish: *Clarias* spp. *Heterobranchus* and their hybrid fry under outdoor nursery management system. National institute for freshwater fisheries research annual report 1996. pp 115-123.
- de Graaf GJ, Galemoni F, Banzoussi B, 1995. Artificial reproduction and fingerling production of the African catfish, *Clarias gariepinus* (Burchell 1822), in protected and unprotected ponds. *Aquaculture Research* 26: 233-242.
- FAO, (2004). World aquaculture supply of catfish and tilapia. FAO Fisheries Report No. 733, Food and Agriculture Organization, Rome, Italy, pp: 46.
- Grobler JP, Du Perez HH, Van der Bank FH, 1992. A comparison of growth performance and genetic traits between four selected groups of African catfish (*Clarias gariepinus* Burchell 1822). *Comp. Biochem. Physiol* 102: 373 –377.
- Legendre, M., G.G. Teugel, G. Carty and B. Jalabart, 1992. A comparative study on morphology, growth rate and reproduction of *Clarias gariepinus* (Burchell 1822), *Heterobranchus longifilis* (Valenciennes 1840) and their reciprocal hybrids (Pisces: Clariidae). *J. Fish Biol.*, 40: 59-79.
- Management. (pp 625 630).
- Nwadu, F. O. (1993). Inducing oocyte maturation, ovulation and spawning in African catfish, *Heterobranchus longifilis* Valenciennes (Pisces: Clariidae). Using frog pituitary extract. A publication by Aquaculture and Fisheries
- Olufeagba, S. O., Aluko, P. O., Omotosho, J. S., Raji, A. and Hassan, B. (1999): Optimum conditions for inducing tripoidy in *Heterobranchus longifilis* (Valenciennes 1840). Proceedings of the 12th Annual Conference of Biotechnology Society of Nigeria. pp 52 55.
- Otema, Z. J; Rodriquees, J. N.; Kouassi, C. K. HRM, S. and Agnes, J. P. (1996): Testicular structure, spermatogenesis and sperm cryopreservation in the African Clariid catfish *Heterobranchus longifilis* (Valenciennes, 1840) *Aquaculture Research*, 27: 805 813.
- Ovie, S. I., Adepoju, F. and Adigun, O. (1997). Growth, survival and nutritive value of the post larvae of *Heterobranchus longifilis* fed *moina* and mixed zooplankton. National Institute for Freshwater Research Annual Report 1997; 1 6.
- Teugels GG, Guyomard R, Legendre M, 1992. Enzymatic variation in African clariid catfishes. *Journal of Fish Biology* 40: 87 – 97.
- Van der Waal, B.C.W. (1998). Survival strategies of sharptooth catfish *Clarias gariepinus* in desiccating pans in the northern Kruger National Park, Koedoe - African Protected Area. *Conservation and Science*, 41: 131-138.

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Nucleotide And Amino Acid Sequencepolymorphisms In The Insulin Like Growth Factor (IGF-I) of Nile Tilapia (*Oreochromis niloticus*) From Nigeria And Senegal Water Bodies

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Abstract

In the last few years, sea level changes with widespread transgressions and regressions have affected salinity levels across the Senegal River Delta which has had negative impact on the freshwater fish farm productions across the region. Available information indicates that the salinity of surface water is mostly controlled by operational management plan of the river water level (that deliver high volumes of fresh water and perturb natural salts balance after dams building). The high salt in a tilapia fish farm location is considered potentially stressful to fish and, therefore, predisposing to pathogens and slow growth. All individual samples were screened for genetic variation by a gene specific PCR reaction with the primers (IGF-I forward-5'-CTTGGACGAGTAGGAGGCAAATG-3' and IGF-I reverse-3'-AAATACAAGCAAGCGATAAGAA-5') of 447bp (IGF-I, GenBank accession AF033797). Nucleotide and amino acid sequences obtained were edited and aligned and a phylogram was created using Clustal O (version 1.2.4) multiple sequence alignment software. This study was aimed at identifying the variability and assess the novel nucleotide and amino acid polymorphism present in the growth gene of *Oreochromis niloticus* from the two West African sub-regions (Nigeria and Senegal). High polymorphisms were detected for both the nucleotides and amino acids on selected strains of the tilapia and the phylogenetic tree generated revealed lower similarities between ONN and ONS and higher similarities among ONN1 and ONN2 and among ONS1 and ONS2.

Key words: Salinity, Insulin-like growth factor I (IGF-I), nucleotide polymorphism, amino acid polymorphism, *Oreochromis niloticus* Nigeria (ONN) and *Oreochromis niloticus* Senegal (ONS).

Introduction

Tilapia is not only widely accepted to African consumers but also to other parts of the world as it represents the species of choice due to its high growth rate, significant tolerance to environmental stresses, ease of reproduction and its unquestionable market demand. Nile tilapia (*Oreochromis niloticus*) is considered the leading tilapia species. Although, this species is native to Africa (Trewavas, 1983; McAndrew, 2000) but it has great economic significance to the global fisheries and aquaculture sector (Nyingiet *et al.*, 2009 and Fatsiet *et al.*, 2020). Therefore, its contribution demands research activities in different areas of aquaculture (Shimaa *et al.*, 2014 and Esmail, 1997). The successful commercial culture of Nile tilapia has previously been attributed to its robust adaptiveness to new environments (Aloo, 2003) and different environmental conditions (Firmat *et al.*, 2013). Its populations have been observed to have rapidly adapted to various environments outside its native home of Africa by evolving outstanding ecological and physiological features, making them highly successful invaders throughout the tropical and subtropical regions (Trewavas, 1983; Canonico *et al.*, 2005; Firmat *et al.*, 2013), and have even been shown to adapt to extreme environments (Nyingi *et al.*, 2009; Ndiwaet *et al.*, 2014).

Oreochromis niloticus as a Cichlid are well known for their complex genetic structure (Kaufman, 1992; Meyer, 1993; Abila *et al.*, 2004; Kerschbaumer and Sturmbauer, 2011; Hashem *et al.*, 2020). Variations in phenotypic traits, regulation in gene expression, and the differential transmission of allelic combinations are some major factors considered essential for species and population diversity (Gagnaire *et al.*, 2013, 2015); principally, however, ecological diversity is a prime factor bonding the environment, selection pressure, and species peculiarity during diversity (Gagnaire *et al.*, 2013). Over the past millennia, sea level changes with widespread transgressions and regressions have affected salinity levels across major Senegal Rivers especially once upon a time freshwater Senegal River Delta (Diaw *et al.*, 2020) and this has had adverse effect on the sea food production in the region especially tilapia production in the Senegal river basin (Diouf and Albaret, 1996).

Due to this observed higher salinity difference and subsequent decline in fish farming activities but prevalence of some *O. niloticus* strains in the saline region of Senegal, we decided to employ the use of IGF-1 factor to examine the genome of this species by profiling its nucleotide and amino acid. Although the application of genomics in

aquaculture is still at the early stages but the use of Single Nucleotide Polymorphisms (SNPs) employed in this study have become a focal point in molecular marker development since they are the most abundant polymorphism in any organism, adaptable to automation, and reveal hidden polymorphism not detected with other markers and methods (Hecker *et al.*, 1999). SNPs are most reliable for genomic wide association studies (GWAS) because linkage instability can be detected with high-density SNP coverage of the genome when working with production or performance traits as it is in the present study. The IGF-1 factor is known to encode growth proteins (Cuevas-Rodríguez *et al.*, 2016), which are vital to the significant growth rate difference between Nile tilapia and other tilapia fish species Sokenu *et al.*, 2020).

Materials and methods

Fish Sample collection and identification

Livestilapia fishes comprising 20 units of *Oreochromis niloticus* from Nigeria (ONN) and 20 *Oreochromis niloticus* fish from Senegal (ONS) were sourced from Epe river, Epe (latitude 6°35'2" N and longitude 3°59'0" E), Lagos state, Nigeria, and Senegal river basin by Diama dam (latitudes 15.450° N and longitude 15.400° W), Senegal respectively. The caudal fins of the fish samples were clipped and transferred into different plain 10ml sterile tubes each containing 4mL absolute ethanol. Identification of the fish samples were achieved from description checklist and identification keys (FAO, 1996; Froese and Pauly, 2003).

DNA extraction and amplification

Genomic DNA was isolated from the caudal fin tissue of the fish samples using modified chlorophenol/isoamyl/alcohol protocol according to Sambrook and Russell (2001) on bench at biotechnology laboratory of NIOMR, Badore outstation, Nigeria. The integrity of the DNA was checked on 1% ethidium bromide-stained agarose gel electrophoresis and the isolate was stored at -20°C prior PCR amplification.

All individuals were screened for genetic variation by a gene specific PCR reaction with the primers (IGF-I forward- 5'-CTTGGACGAGTAGGAGGCAAATG-3' and IGF-I reverse- 3'-GAAATACAAGCAAGCGATAAGAA-5') of 447bp (IGF-I, GenBank accession AF033797). The DNA amplification was carried out in accordance with Buie *et al.*, 2017.

Nucleotide and amino acid sequencing

Four of the amplicons from both water bodies were selected from the amplification of the *O. niloticus* (2 from Nigerian water (ONN 1 & ONN2) and 2 from Senegal water (ONS1 & ONS2) which were bidirectional sequenced in an automatic sequencer (ABI 3500XL Genetic Analyzer).

Nucleotide sequences obtained were edited and aligned and a phylogram was created using Clustal O (version 1.2.4) multiple sequence alignment software. The nucleotide Polymorphisms were discovered by visual analysis while the amino acid sequence was obtained by translation of the DNA sequence of each species using BioLign alignment software (version 4.0.6.2) and the amino acid sequence was aligned, and their Polymorphisms were analyzed using Clustal O (version 1.2.4) multiple sequence alignment software. A polymorphic position was defined as a real polymorphism when it was present in more than one individual and was confirmed by the forward and reverse sequence.

Results and Discussion

DNA extraction and amplification

The amplified PCR product of the extracted DNA run on 1.5% ethidium bromide-stained agarose gel demonstrated that IGF-I genes had the same bands which demonstrated equal length and size of the gene in the Tilapia fish samples as shown on plate 1, where M is the known 50bp- 10 kb DNA ladder.

Nucleotide and amino acid sequence and analyses

The sequence alignment generated for the forward and reverse primers of IGF-1 of the four *Oreochromis niloticus* from Nigeria and Senegal water bodies were shown in Figure 1 and 2 respectively while tables 1 and 2 shows the nucleotide polymorphisms detected at the positions 404(T/G), 405(G/T), 406(T/A), 407(A/T), 410(T/C) and

411(C/A) of the forward reaction sequence and those detected in the reverse reaction sequence at positions 404(T/C), 406(C/T), 407(G/C), 408(T/G), 409(C/T), 411(A/C), 413(G/A), and 414(A/G) respectively.

The phylogenetic tree revealed lower similarities between ONN and ONS and higher similarities among ONN1 and ONN2 and among ONS1 and ONS2 (Figure 3). The lower similarity between ONN and ONS might imply a high genetic polymorphism and a clear indication of their different sources and ancestry.

A total of 137 and 134 amino acid sequence was translated from the DNA sequence of *Oreochromis niloticus* from Nigeria and Senegal respectively as shown in Figure 4 and 5. The alignment of these sequences revealed seven (7) Variations at positions 24, 58, 69, 75, 79, 154 and 155 as shown in Figure 6.

The polymorphisms observed are as follows; position 24; C (cysteine) in ONN to I (isoleucine) in ONS, position 58; L (leucine) in ONN to * (stop codon) in ONS, position 69; S (serine) in ONN to N (asparagine) in ONS, position 75; R (arginine) in ONN to N (asparagine) in ONS, position 79; M (methionine) in ONN to I (isoleucine) in ONS; position 154; T (threonine) in ONN to C (cysteine) in ONS and position 155; I (isoleucine) in ONN to L (leucine) in ONS (Table 3).

The DNA sequences gotten from primer used in this study was about 447bp in agreement with the result obtained by Cuevas-Rodríguez *et al.*, (2016) and Sokenuet *et al.*, (2020).

This study was aimed at identifying and developing novel nucleotide and amino acid polymorphism present in the growth gene of *Oreochromis niloticus* from the two West African regions (Nigeria and Senegal). These polymorphisms might be responsible for differential growth and large sizes of *Oreochromis niloticus* in these two regions coupled with the different salinity of their water bodies. Such genetic markers can be screened in natural population studies of adaptation and associate them to phenotypic polymorphisms in fish evolution. They will also be useful in marker assisted selection in breeding.

Table 1: Observed polymorphisms between the forward nucleotide sequence reaction of the *Oreochromis niloticus*.

POSITION	ONN	ONS
404	T	G
405	G	T
406	T	A
407	A	T
410	T	C
411	C	A

Table 2: Observed polymorphisms between the reverse nucleotide sequence reaction of the *Oreochromis niloticus*.

POSITION	ONN	ONS
404	T	C
406	C	T
407	G	C
408	T	G
409	C	T
414	A	G

>ONS2F																					
1	CTT	TTA	ATG	TCT	GTG	TAA	TGT	AGA	TAA	ATG	TGA	GGG	ATT	TTC	TCT					45	
1	L	L	H	S	V	*	C	R	*	H	*	G	I	F	S					15	
46	CTA	AAT	CCG	TCT	CCT	GTT	CGC	TAA	ATC	TCA	CTT	CTC	CAA	AAC	GAG					90	
16	L	N	P	S	P	V	R	*	I	S	L	L	Q	N	E					30	
91	CCT	GCG	CAA	TGG	AAC	AAA	GTC	GGA	ATA	TTG	AGA	TGT	GAC	ATT	GCC					135	
31	P	A	Q	W	N	K	V	G	I	L	R	C	D	I	A					45	
136	CGC	ATC	TCA	TCC	TCT	TTC	TCC	CTG	TTT	TTA	ATG	ACT	TTA	AAC	AAG					180	
46	R	I	S	S	S	F	S	L	F	L	M	T	L	N	K					60	
181	TTC	ATT	TTC	GTC	GGG	CTT	TGT	CTT	GTG	GAG	ACC	CGT	GGG	GAT	GTC					225	
61	F	I	F	V	G	L	C	L	V	E	T	R	G	D	V					75	
226	TAG	CGC	TTT	TTC	CTT	TCA	GTG	GCA	TTT	ATG	TGA	TGT	CTT	CAA	GGT					270	
76	*	R	F	F	L	S	V	A	F	M	*	C	L	Q	G					90	
271	AAC	TTA	CCT	GAT	TTC	CTT	TGA	CAC	TAT	ACA	TTA	TCA	CCT	TGA	TTC					315	
91	N	L	P	D	F	L	*	H	Y	T	L	S	P	*	F					105	
316	TTC	ACT	TGC	TCA	CTA	TTT	GCA	CAG	AGC	ATC	CTC	GCC	TAC	TTT	AAA					360	
106	F	T	C	S	L	F	A	Q	S	I	L	A	Y	F	K					120	
361	AAG	AAA	CAA	TAA	AAG	GGG	ATT	CTT	ATC	GCT	TGC	TTG	TAT	TTC						402	
121	K	K	Q	*	K	G	I	L	I	A	C	L	Y	F							

Figure 5: Translation of DNA sequence of IGF-1 of *Oreochromis niloticus* from Senegal(ONS) to amino acid.
* mean stop codon.

CLUSTAL O (1.2.4) Multiple sequence alignment for amino acids

ONN1F	VFSFECLCNVDKCEGF--SL*IRLLFAKSHFSKTSRLNGTKSEY*DVTLPASHPLSPCF*	55
ONN2F	---MVCVM*INVRDFLSKSVSCSLNL-----TSPKRAC--	29
ONS1F	-----CPV*CR*M*GIFSLN-----PSPVR*I--	18
ONS2F	-----LLMSV*CR*M*GIFSLN-----PSPVR*I--	20
:		
ONN1F	*L*TSFSSGFVLWRPVGMSAF-----S-----FQWHLCD	84
ONN2F	---AMEQS---RNIEM*HCP-----HLILFLPVFNDFKQVHFRRALSCGDPWGCLA	73
ONS1F	---SLLQNEPAQWNKVGLRCDIARISSSFSFLMTLNKFI-----	56
ONS2F	---SLLQNEPAQWNKVGLRCDIARISSSFSFLMTLNKFI-----	58
: .. : . :		
ONN1F	VFK-----VTYLISFDTHYHLDSLALHYL-----HR	111
ONN2F	LFPFSGIYVMSR*L-T*FPLTLYITLILHLITICTEHPRL*KETIKGD-----	120
ONS1F	---FVGLCLVETRGDV*RFFLSVAF-----M*CLQGNLPDFL*HYTLSP*FFTCSLFAQ	103
ONS2F	---FVGLCLVETRGDV*RFFLSVAF-----M*CLQGNLPDFL*HYTLSP*FFTCSLFAQ	105
: . . * :		
ONN1F	ASSPTLKRNNKRGFLSLALYF	132
ONN2F	-----SYRLFCIS-	128
ONS1F	SILAYFKKKQ*KGILIACLYF	123
ONS2F	SILAYFKKKQ*KGILIACLYF	125
. . :		

Figure 6: Alignment of the amino acid sequence of the IGF-1 of *Oreochromis niloticus* from Nigeria and Senegal.
* mean stop codon.

Table 3: Detected Polymorphisms in the amino acid sequence of the *Oreochromis niloticus*.

SEQUENCE POSITION	ONN	ONS
24	L	*
58	C	I
69	S	N
75	R	N
79	M	I
154	T	C
155	I	L

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References

- Abila, R., M. Barluenga, J. Engelken, A. Meyer & W. Salzburger, 2004. Population-structure and genetic diversity in a haplochromine fish cichlid of a satellite lake of Lake Victoria. *Molecular Ecology* 13(9): 2589–2602.
- Aloo, P. A., (2003). Biological diversity of the Yala Swamp lakes, with special emphasis on fish species composition, in relation to changes in the Lake Victoria Basin (Kenya): threats and conservation measures. *Biodiversity and Conservation* 12(5): 905–920.
- Bui, T.G.T., Hoa, N.T.L, Yen, J., Schafleitner, R. (2017). PCR-based assays for validation of single nucleotide polymorphism markers in rice and mungbean. *Hereditas*. 154(3):2-13
- Canonico, G. C., A. Arthington, J. K. McCrary and M. L. Thieme, (2005). The effects of introduced tilapias on native biodiversity. *Aquatic Conservation: Marine and Freshwater Ecosystems* 15(5): 463–483.
- Cuevas-Rodríguez B.L., Sifuentes-Rincón A.M, Ambriz-Morales P, García-Ulloa M, Valdez-González FJ, Rodríguez-González H (2016). Novel single nucleotide polymorphisms in candidate genes for growth in tilapia (*Oreochromis niloticus*). *Revista Brasileira de Zootecnia*. 45(6):345-348.
- Diaw M, Mall I, Madioune HD, Leblanc M, Faye S and Travi Y (2020). Historical and Recent Evolution of Waters Salinity in the Senegal River Delta. *Int J Water Res* 2(2): 112: <https://doi.org/10.36266/IJWR/112>
- Diouf. P.S. and J.J. Albaret (1996). Tilapia culture in the Senegal river basin and the causes of its failure. p. 488-499. In R.S.V. Pullin. J. Lazard. M. Legendre. J.B. Amon Kothias and D. Pauly (eds.) The Third International Symposium on Tilapia in Aquaculture. *ICLARM Conf. Proc.* 41. 575 p.
- Esmail, M. F. (1997). Effect of some heavy metals on growth performance and chromosomal behaviour of some local tilapia species. *Ms. Thesis*. Tanta University.
- FAO (1996). Species identification field guide for fishery purposes, *Food and Agriculture Organisation*, United Nation, Rome, 265pp.
- Fatsi, P. S. K., Hashem S., Kodama A., Appiah E. K., Saito H., Kawai K. (2020). Population genetics and taxonomic signatures of wild Tilapia in Japan based on mitochondrial DNA control region analysis. *Hydrobiologia* (<https://doi.org/10.1007/s10750-020-04203-3>)
- Firmat, C., Alibert, P., Losseau, M., Baroiller, J.-F. & Schliewen, U. K. (2013). Successive Invasion-Mediated Interspecific Hybridizations and Population Structure in the Endangered Cichlid *Oreochromis mossambicus*. *PLOS ONE* 8, e63880, <https://doi.org/10.1371/journal.pone.0063880>.
- Froese R, Pauly D (2003). Fish Base. Electronic Publication. www.fishbase.org.
- Gagnaire, P. A., S. A. Pavé, E. Normandeau and L. Bernatchez, (2013). The genetic architecture of reproductive isolation during speciation-with-gene-flow in lake whitefish species pairs assessed by rad sequencing. *Evolution* 67(9): 2483–2497.
- Gagnaire, P. A., T. Broquet, D. Aurelle, F. Viard, A. Souissi, F. Bonhomme and N. Bierne, (2015). Using neutral selected, and hitchhiker loci to assess connectivity of marine populations in the genomic era. *Evolutionary Applications* 8(8): 769–786.
- Hashem, S., K. Kawai, P. S. K. Fatsi, A. Kodama and H. Saito (2020). Genetic relationships of cichlid fishes from Lake Malawi based on mitochondrial DNA sequences. *Limnology* 21: 151–163.
- Kaufman, L. (1992). Catastrophic change in species-rich freshwater ecosystems. *BioScience* 42(11): 846–858.
- Kerschbaumer, M. and C. Sturmhuber, (2011). The utility of geometric morphometrics to elucidate pathways of cichlid fish evolution. *International Journal of Evolutionary Biology*. <https://doi.org/10.4061/2011/290245>.
- McAndrew, B. J. (2000). Evolution, phylogenetic relationships, and biogeography. Tilapias: Biology and Exploitation. Springer, Dordrecht: 1–32.
- Meyer, A. (1993). Evolution of mitochondrial DNA in fishes. *Biochemistry and Molecular Biology of Fishes* 2: 144.
- Ndiwa, T. C., D. W. Nyingi and J. F. Agnese, (2014). An important natural genetic resource of *Oreochromis niloticus* (Linnaeus, 1758) threatened by aquaculture activities in lobo drainage, Kenya. *PLoS ONE* 9(9): 106972.
- Nyingi, D., De Vos, L., Aman, R. & Agnès, J.-F. (2009). Genetic characterization of an unknown and endangered native population of the Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758) (Cichlidae; Teleostei) in the Lobo Swamp (Kenya). *Aquaculture* 297, 57–63.
- Sambrook J, Russell DW (2001). Molecular Cloning: A laboratory Manual. 3rd edition. Cold Spring Harbour Laboratory Press.
- Shimaa A.K, Shabaan A.H, Abeer F.E, walaa S.H (2014). Genetic polymorphism in *IGF-II* Gene and its relationship with growth rate in Tilapia Nilotica. *Alexandria Journal of Veterinary sciences* 43:26-32.

- Sokenu B.A, Oguntade O.R, Ogunkanmi L.A, Oketoki T.O, Ukenye E.A, Usman A.B (2020). Comparative study of single nucleotide Polymorphisms (SNPs) of a candidate growth gene IGF-I In *Oreochromis niloticus* and *Sarotherodon melanotheron*. *African Journal of Biotechnology*. 19(8):546-555.
- Trewavas, E. (1983). Tilapiine fishes of the genera *Sarotherodon*, *Oreochromis*, and *Danakilia*. British Museum (Natural History).

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Effects of Brood Stock Size on Fecundity and Hatchability of African Catfish (*Clarias gariepinus*)

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Abstract

A research was conducted in the research fish farm of the Department of Fisheries and Aquaculture, Kogi State University Anyigba, to study the effect of broodstock size of African cat fish (*Clarias gariepinus*) on fecundity and hatchability in an indoor fish hatchery. Three female brood stocks of different sizes by weight (1.9kg, 1.6kg and 1.1kg) and two male brood stocks purchased from two commercial farms at Lokoja were used for the study. The brood stocks were induced with synthetic hormone (ovaprim), dosage of 0.5ml/kg of body weight of the brood stock, they were stripped of their eggs in separate plastic containers as they ovulated. The eggs stripped were counted using gravimetric method for each brood stock to estimate the fecundity. Some quantities of eggs were counted from each brood stock and fertilized, incubated and hatched. The hatched larvae were counted using volumetric methods. There was significant different ($p < 0.05$) in fecundity between the three brood stocks. Broodstock of weight 1.9kg has the highest fecundity with the number of (97909 eggs) followed by 1.1kg (59331 eggs) the least is 1.6kg brood stock (27902 eggs). There was also significant different ($p < 0.05$) in the hatchability among the different sizes of female brood stock as the hatchability of 1.9kg brood stock was higher (4787) than 1.6kg brood stock (3550). However the hatchability of 1.1kg brood stock was higher (4037) than that of 1.6kg brood stock (3550). The percentage hatchability followed the same pattern. The result from the study showed that weight of female brood stock does not progressively affect the fecundity and hatchability of eggs.

Keywords: Female Broodstock, African catfish, fecundity and hatchability.

Introduction

In the recent years there has been a global attention on aquaculture as an important source of food, income and livelihood for hundred to millions people around the world. According to Food and Agriculture Organisation (FAO) (2016), Aquaculture is the fastest growing food production sector and an important component in many poverty alleviation and food security programs. As the world population increases, the demand for fish in the world also increases. Despite the high preference for fish and fishery products in Africa, the per capital consumption of fish and fishery products is still very low (FAO 2000). There is an increase attention globally on aquaculture because of the needs to augment fish production from the wild (FAO 2016). In 2014, according to FAO, (2016). The aquaculture sectors contributions to the supply of fish for human consumption overtook that of wild-caught fish for the first time. Although total capture from wild fisheries exceed that of aquaculture (73.8 million tonnes), often (146.3 million tonnes) for human consumption. Rearing cultured fish species under controlled environment has proved to be a successful method of enhancing fish supply. Among all, cat fish are important to the sustainability of the aquaculture industry of Africa especially Nigerian. Their method of propagation is well documented and understood, but the seeds (fingerlings and fry) supply could not meet fish farmers demand (Atagubaet *al.*, 2013). For successful production of viable fish seeds it is important to consider the fecundity and hatchability of egg by the female brood stock. Fecundity is the number of ripening eggs in the female fish prior spawning while hatchability is the total number of eggs hatched after fertilization.

Materials and Methods

Study location

The study was conducted in an indoor hatchery complex of the department of fisheries and aquaculture, Faculty of Agriculture Kogi State University, Anyigba Kogi State located within $7^{\circ} 28' 45.7''$ N and $7^{\circ} 11' 54.2''$ E.

Collection of brood stock (*Clarias gariepinus*)

Total numbers of five brood stocks were purchased (three female and two males) from Food Way Integrated farms Lokoja and Ajuma farms Ltd Abuja. The three female came in different weight as 1.9kg, 1.6kg, 1.1kg respectively. The mature male brood stock and the female were kept in separate tanks to avoid bullying.

Experimental procedure:

The female brood stocks were weighed and induced with synthetic hormone (ovaprim) at dosage of 0.5/kg body weight using five mill syringe injection, administered intramuscularly (above the lateral line 45° towards the head region). The milt were collected by sacrificing the male in which the abdomen was dissected and the testes removed clean up the blood stain then cut through with sharp razor blade to obtain the milt which was squeezed into hydrosaline solution for preservation prior to the expiration of latency period of the female. The female brood stocks went through latency period for 10 hours at temperature of 27°C. They were stripped of their eggs by applying slight pressure on the abdomen. The eggs were collected into three cleaned well dried plastic bowls separately for each female brood stock. The stripping was done continuously until there were signs of blood coming out with the eggs, and this is to ensure that almost all eggs have been stripped. Fertilization was done by mixing the milt with the eggs and stirred for some minutes with a plastic spoon, then the fertilized eggs spread on the nest (kakaban) in plastic bowls filled with bore hole water for incubation

Estimation of fecundity: -Fecundity has been considered as the numbers of ripened eggs in the female fish prior to spawning (Bagenal and Braum, 2017). Gravimetric method was used for the estimation of fecundity. This was done by taking the weight of the eggs of each sample. The weight of the eggs was determined by taking out 10 egg from each sample and weighed with sensitive balance and extrapolate to get the number of egg. The ovary (gonad) weight was taking by subtracting the weight of the fish after stripping from the initial weight. The value for fecundity is proportional to the ovary weight. The number of egg for the sample was estimated using the following equation.

$$\text{Fecundity (F)} = \frac{\text{Average no of eggs} \times \text{weight of gonads}}{\text{Weight of subsample}} \quad (\text{Yelden and Avsar, 2000})$$

Estimation of hatchability:

The fertilized eggs for brood fish were divided into three parts i.e. each was replicated thrice for incubation process. During the incubation, the plastic bowls used were aerated using aquarium pump and were left for 30 hours for hatching to take place and in the process, flow through was done as bowls were connected to water source. The hatched larva were counted using volumetric method described by Absalom *et al.*, (2017) in which a sample of one liter of water was collected and the number of hatchings will be estimated from the sample by extrapolation. The numbers of the fertilized eggs were determined by multiplying the weight of the fertilized eggs in grams by 700. (1g=700egg) (Viveenet *al.*, 2013)

$$\text{Percentage hatchability} = \frac{\text{Number of hatched egg}}{\text{Number of fertile egg incubated}} \times 100$$

Statistical analysis:

The data on fecundity, hatchability and % hatchability obtained were subjected to one way ANOVA using SPSS statistical package (version 20) software and the means separated using students T-test.

Results and Discussions

The results of the fecundity showed significant differences ($P < 0.05$) between the three different brood stock sizes. The female brood stock with initial weight of 1.9kg had fecundity of 97909 followed by the female brood stock with the weight of 1.1kg (59331). The least fecundity recorded was with the brood stock with initial weight of 1.6kg (27902). The results of the hatchability also showed significant different ($P < 0.05$) among the three different weight of the brood stock, as hatchability of brood stocks which had weight of 1.9kg, 1.6kg, 1.1kg were 4783, 3550, and 4037 respectively. The results of percentage hatchability showed a significant different among the female brood stocks. The brood stock that had weight of 1.6kg has the highest percentage hatchability of 12.743% followed by brood stock with the weight of 1.1kg (6.837%) and 1.9kg (4.940%). The result for fecundity, hatchability and percentage hatchability are shown in Table 1 below.

The results of fecundity showed significant different among different weight of female brood stocks. This result did not agree with research of Raina (2017) who stated that, fecundity depends on the body length and weight. However, Nikolsky (2014) attributed the result to the availability of food. But Hossain *et al.*, (2017) attributed to the physiology of the fish and their environment as the controlling factors for variation in fecundity among same species of different sizes. This statement also agreed with results of Bodola (2016) who found that ovaries made up a larger percentage of body weight in smaller fish than in larger fish. The variation in hatchability as related to size was equally observed by De Graaf *et al.*, (2012) and Raina (2017) who stated that hatchability depends on fecundity. But

Absalomet *al.*, (2017) observed hatching rate to increased and ranging from 48:00 to 74:30 in common carp, (*Cyprinus carpio*) with lower weight than higher one.

Table 1: Effects of different weight of female brood stocks on fecundity, hatchability and % hatchability

Brood Stock weight (Kg)	Fecundity	Hatchability	% Hatchability
1.9	97909 ^a	4783.00 ^a	4.940 ^c
1.6	27902 ^c	3550.00 ^c	12.743 ^a
1.1	59331 ^b	4037.00 ^b	6.837 ^b
LSD	135560	407.60	0.6502
SEM	3453.50	103.80	0.1656

Means with same letters in a column are not significantly different ($P < 0.05$)

Conclusion

This study revealed that there was a significant different in fecundity and hatchability among the different weight of female brood stock of *Clarias gariepinus*. It is then concluded that the weight of female brood stock of *Clarias gariepinus* doesn't affect fecundity and hatchability of the brood fish. This was observed in the result as the smaller weight female had more eggs than the bigger weight fish and the hatchability followed the same pattern.

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References

- Absalom, K.V, Anpe J.A and Okunsebor S.A (2017). The fecundity and egg size of *Clarias gariepinus* in pandam lake, Qunpan L.G.A Plateau state Nigeria, African former of Agricultural research 6(6): 1291 – 1295.
- Ataguba, GA, Victor T.O and Onwuka, M.C (2013) Relationship between Broodstock weight combination and spawning success in African catfish (*Clarias gariepinus*). *Creation Journal fisheries* 71:176 181.210P.
- Bagenal T.B and Braum, S.D (2017). Aspect of fish fecundity. Ecology of fresh water fish production, Blackwell scientist pub. PP 75 – 101 Oxford.
- Bodola A. (2006). Life history of the gizzard shad. *Dorosomacepedianum*_(Lesueur). In western lake Erie U.S fish wild served. Fish bull 65.391-425
- De graaf, Glemoni, F and banzoussi, B (2012). The artificial reproduction and fingerlings production of the African cat fish (*Clarias gariepinus*) in protected and unprotected ponds. *Aqua red* 26 : 233-242.
- Food and Agricultural organization: (2000) FAO Aquaculture news letter. April 2000, 24 – 37
- Food and Agriculture Organization: FAO (2016) the state of World Fisheries and Agriculture 2016. Contribution to food security and nutrition for all. Rome 200P.
- Hossain, M.A, S. Panreen and M.A. Rahman (2017) fecundity of *Nandus nandus* (Ham-Buch). *J. Bio Sc*, 5:305-307
- Nikolsky G.V. (2014). The ecology of fishes. Lagon academic process, New York: 1-352
- Raina Rahman (2017). Observations on the fecundity and spawning behaviour of *Schizothorax socinus*. Heckle from dal lake, Kashmir. *Indonesia Journal of fish* 24:201-203
- Viveen, W,J,A. Richter, C,J,J, Van-ordit, P,CT. Jansee, J, A ,L and Huisman E.A , (2003). Practical manual for the culture of African catfish (*Clarias gariepinus*) section for research and Technology. Box 2006, 5600EB. The hague, The Netherlands, P.121
- Yelden K and Avsar S.R (2000). Fecundity of some fresh water eel. *Journal of zoology* 10:60 – 67.

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Use of Some Synthetic Hormones at Varying Dosage to Determine the Fertilization, Hatching and Survival of African Catfish (*Clarias gariepinus*)

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Abstract

Induced breeding of *Clarias gariepinus* was conducted to investigate effect of synthetic hormone on reproductive performance, the broodstock were collected from a recognized fish farm and were injected with three hormones such as Ovaprim, Ovulin and Ovaspec at 0.1, 0.3 and 0.5ml/kg body weight. The results indicated statistical difference ($P < 0.05$) in the number of ovulated eggs induced in *Clarias gariepinus* broodstock based on their dosage. Among all the treatments, 0.3ml/kg which is lower than the recommended dose of the three hormones recorded the highest value in terms of fecundity, fertility rate, hatchability rate and survival rate. The present study demonstrates that, *Clarias gariepinus* mean body weight of 600-800g can ovulate and spawn successfully using any of these hormones. Comparative cost of hormone indicated that, Ovaspec was relatively cheaper compared to Ovulin and Ovaprim therefore Ovaspec is recommended to induce spawning of *C. gariepinus*.

Keywords: Aquaculture, Artificial propagation, Synthetic hormones, *Clarias gariepinus*,

Introduction

Aquaculture has been growing strongly in many countries, giving rise to worldwide efforts to eliminate hunger and malnutrition by supplying fish and other aquatic products rich in protein, essential fatty acids and minerals (FAO, 2012). African catfish species (*Clarias gariepinus* or *lazera*) are the most resistant, widely accepted, and highly valued fish cultivated in Nigeria (Adewumi and Olaleye, 2011). The catfish (*Clarias gariepinus*) is a remarkable fish species reared all over the country and have excellent commercial value in Nigerian markets (Adewolu and Adeoti, 2010). It has the credentials of fast growth, resistance to disease and handling stress. As the world population increases, the demand for fish also grows. The per capital consumption of fish is still very low despite the high preference for fish and fisheries products in Africa FAO (2000). Artificial propagation of fish is the most reliable way of ensuring the availability of good quality fish seed all year round and sustainability of the aquaculture industry. It involves using natural (hypophysation) or synthetic hormones to induce ovulation and spawning in fish farms (Viveen WJAR, *et al* 1985). One of the major constraints to fish breeders is the cost of procurement of these hormones. According to Madu, (2006), hormone input accounts for about 50-60% of the recurrent expenditure of a catfish fingerling production project in Nigeria. The major constraints for culturing fish are a short supply of quality seed and the dependency on wild sources, which is unreliable, time-consuming and uneconomical. To overcome such problems, induce spawning is the only alternative method for quality seed supply and production (Sharma *et al.*, 2010). It is based on this study that this study was conducted to determine the efficiency and the cost-benefit of some synthetic hormones used in fish breeding.

Materials and Methods

Experimental Site

The experiment was conducted in the hatchery unit of teaching and research farm of the Department of Water Resources, Aquaculture and Fisheries Technology, School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, Gidan Kwano Campus Niger State.

Experimental Design

The experiment was designed in 3×3 Factorial Design at the hatchery unit of the Department of Water Resources Aquaculture and Fisheries Technology (WAFT), Federal University of Technology, Minna. The Niger State of Nigeria. The experiment had 3 hormones (Ovprim, Ovulin and Ovaspec) with 3 dosage levels (0.1, 0.3 & 0.5ml/kg) for each hormone, and each level was in triplicate. The experiment lasted for 14 days after hatching.

Broodstock Selection

Fifteen broodstocks of *Clarias gariepinus* was obtained from a well-known functioning fish farm for the experiment. The broodstock was selected based on their external morphological characteristics (Ayinla *et al.*, 1994); female with a well-distended abdomen and round urogenital papilla and male with a protruded papilla. Before hormonal treatment, the selected brooders were conditioned for about 1-4 days (Ngueku, 2015).

Hormone Administration

Synthetic hormones (Ovaprim, Ovulin and Ovaspec) were purchased at Kado Fishmarket, Life-Camp Abuja, Nigeria. The female brooders were weighed separately. The appropriate quantity of the hormonal substances was calculated based on their body weight at 0.1, 0.3 and 0.5mg/kg dosage for each of the three hormones used. The hormones were administered in three days. Ovaprim, Ovulin and Ovaspec were administered at 0.1ml/kg body weight for the first day while the second day was 0.3ml/kg and 0.5ml/kg for the third day for all the three hormones. All injections are administered intramuscularly in a region of the caudal peduncle above the lateral line, with a 2ml syringe fitted with a needle, after which the fish were kept separately in a plastic bowl for the latency period, which lasted within 9 - 11hrs 26minutes for all the female fish injected for the experiment.

Procurement of Eggs and Milt

After the latency period, some injected fish released eggs themselves while a slight pressure was applied with hand to other females to release the eggs. The injected fish were hand-held firmly with a towel covering the head and around the caudal fin. Before stripping, the abdominal part of the fish was mopped dried with tissue paper to prevent the contact of the eggs with slime, faeces and blood as they stripped (Piper *et al.*, 1989). Ovulated eggs were oozed out and collected in a small container separately by gently pressing the belly, and the female broodfish were weighed again after stripping. According to Hogendoorn and Vismans (1980), the male brooder was sacrificed by carefully dissecting the belly and carefully removing the testis from the ventral wall of the abdominal cavity. The milt sac was collected, wiped clean of blood and water using tissue paper.

Fertilization of Eggs, Incubation and Hatching

A dry method of fertilization was used where the milt sac was cut and squeezed directly onto the eggs. The sexual product is mixed with a feather by gently shaking the bowl for about 1–2 minutes, after which prepared saline solution was added and stirred again for adequate fertilization (Megsbowon *et al.*, 2013). After fertilization, a few freshwater drops were added to activate the eggs. Then 15g of the fertilized eggs were spread homogeneously on the spawning net (Kakaban) inside the incubation tanks for all the treatments in each replicate tank filled with clean and well-oxygenated water free of plankton organism with an air pump (aerator) (Delince *et al.*, 1987). The incubation period for all the treatments range between 22-26 hours, the kakaban with unhatched eggs was removed as soon as hatching was completed. The deformed fry shell and dead unfertilized eggs are siphoned out of the incubation tank, and the fry starts feeding by day three when the yolk sac is fully absorbed.

Statistical Analysis:

Data were obtained and were pooled for each Hormone/treatment mean and were compared by two-way ANOVA by Graph Pad Prism Version 7.04 package.

Calculations

Fecundity was estimated according to (Yelden and Avsar, 2000).

Where:

- $$F_1 = \frac{\text{Overy weight} \times \text{Number of eggs in the sub sample}}{\text{Sub sample weight}}$$
- $$\%Fertility = \frac{\text{Number of fertilize eggs}}{\text{Total Number of eggs counted}} \times 100$$
- $$\%Hatchability = \frac{\text{Number of Hatched eggs}}{\text{Total number of eggs in a atch}} \times 100$$
- $$\%Survival Rate = \frac{\text{Total number of fry at the end of the experiment}}{\text{Total number of fry at the begining of the experiment}} \times 10$$

Result and Discussion

The size of broodstock (*Clarias gariepinus*) used in this study ranges from 600 - 800g (body weight) which is in agreement with de Geef and Jonssen (1996) who reported that the ideal broodstock weight should be between 300-800g as larger eggs are difficult to handle and may also result to egg losses before stripping. All female fishes injected with the three hormones (Ovaprim, Ovulin and Ovaspec) responded well and bred within 8 – 11h 30minutes at a temperature range between 26.8°C – 27.5°C. The result from Fig.1 below shows that Ovulin has the tallest bar, representing the most significant number of eggs at 0.1ml/kg and 0.3ml/kg, followed by Ovaspec and Ovaprim, which has the shortest bar. In contrast, at 0.5ml/kg Ovaprim has the tallest bar followed by Ovulin and Ovaspec. This may be due to the temperature difference in the number of days used for the injection. Also, the result did not go with Shinkafi and Ilesams (2014) who reported that Ovatide recorded higher fecundity for higher dose.

The efficiency of Ovaprim, Ovulin and Ovaspec to induce ovulation of *Clarias gariepinus* are clearly demonstrated in this study. The result demonstrated that, Ovaspec has the highest percentage fertilization rate at 0.1ml/kg (91.01±0.30) and 0.3ml/kg (91.83±0.13) followed by Ovaprim and Ovulin which are not significant at 0.1ml/kg. at 0.5ml/kg there is no significant difference in the percentage fertilization of *Clarias gariepinus* induced with Ovaprim, Ovulin and Ovaspec. The mean fertilization rate of this study is similar to the result obtained by who reported that the highest mean fertilization rate of 92.22% on the Effect of Different Doses of Ovulin Hormone Suspended in Saline on the Induced Breeding Performance of African Catfishes *Clarias anguillaris* and *Clarias gariepinus* in Sokoto, Nigeria. It was indicated that there is no significant difference in the percentage hatchability of *Clarias gariepinus* injected with Ovaprim and Ovaspec at 0.1ml/kg which has the height value followed by the lowest Ovulin (71.26±0.46). while Ovaspec at 0.3ml/kg (78.43±0.52) and 0.5ml/kg (73.95±0.43) are observed to have the highest mean value of percentage hatchability followed by Ovaprim and Ovulin which are not significant. The mean hatching rate was higher than what was obtained by Gbemisola and Adebayo (2014) who used Ovatide and Ovaprim on *Clarias gariepinus* with mean value of 59.70% and 66.37% respectively. The percentage survival of the present investigation as observed from table 1 below, there was statistical difference in the percentage survival of *C. gariepinus* induced at 0.1ml/kg where the highest mean value was observed in Ovaspec (73.23±2.30^a) followed by Ovaprim (50.33±5.36^b) and the lowest Ovulin (31.50±7.09^c). while there is no significant difference in the percentage survival of *Clarias gariepinus* at 0.3ml/kg and 0.5ml/kg. The comparative effect of the three hormones (Ovaprim, Ovulin and Ovaspec) at all level of inducement (0.1ml/kg, 0.3ml/kg and 0.5ml/kg) demonstrated that there is no significant difference on the fertility, hatchability and survival of the 14 days old fry as shown in Table 2 below. The comparative cost of the hormones used in the experiment were determined. *C. gariepinus* broodstock injected with Ovaprim worth (₦512), Ovulin worth (₦352) and Ovaspec worth (₦341).

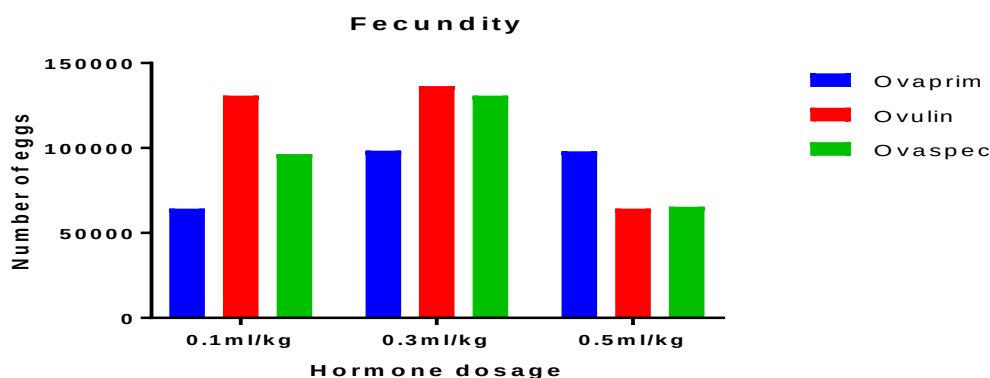


Fig. 1: Chart representing the fecundity assessment of *Clarias gariepinus* induced with Ovaprim, Ovulin and Ovaspec at 0.1, 0.3 and 0.5ml/kg b. wt. dosage.

Table 1: Effect of hormones and levels on induced spawning of *Clarias gariepinus* using OvaprimOvulin and Ovaspec at 0.1, 0.3 and 0.5ml/kg body weight dosage.

Parameters	Hormones		
	Ovaprim	Ovulin	Ovaspec
% Fertility (0.1ml/kg)	90.39±0.30 ^{ab}	89.57±0.13 ^b	91.01±0.30 ^a
% Hatchability (0.1ml/kg)	78.16±0.84 ^a	71.26±0.46 ^b	77.94±0.88 ^a
% Survival rate (0.1ml/kg)	50.33±5.36 ^b	31.50±7.09 ^c	73.23±2.30 ^a
% Fertility (0.3ml/kg)	90.30±0.41 ^b	90.88±0.12 ^b	91.83±0.13 ^a
% Hatchability (0.3ml/kg)	75.86±0.20 ^b	76.40±0.28 ^b	78.43±0.52 ^a
% Survival rate (0.3ml/kg)	67.57±5.68 ^a	74.10±3.47 ^a	79.60±4.49 ^a
% Fertility (0.5ml/kg)	89.69±0.07 ^a	90.14±0.29 ^a	90.45±0.29 ^a
% Hatchability (0.5ml/kg)	69.67±0.58 ^b	72.75±0.30 ^b	73.95±0.43 ^a
% Survival rate (0.5ml/kg)	48.00±15.95 ^a	77.40±1.99 ^a	74.67±2.03 ^a

*Mean values with the same superscript in each row are not significant

Table 2: Comparative effect of hormones at all level on induced spawning of African catfish (*Clarias gariepinus*).

Parameters	Hormones		
	Ovaprim	Ovulin	Ovaspec
% Fertility	90.13±0.22 ^a	90.20±0.38 ^a	91.10±0.40 ^a
% Hatchability	74.56±2.54 ^a	73.47±1.53 ^a	76.77±1.41 ^a
Survival rate (%)	55.97±6.83 ^a	61.00±14.78 ^a	75.83±1.92 ^a

*Mean values with the same superscript in each row are not significant

Conclusion and Recommendation

In conclusion, the present investigation demonstrates that *Clarias gariepinus* to Ovaprim, Ovulin and Ovaspec at 0.3ml/kg body weight which is lower than the recommended dose was found to be the best considering the temperature condition. Therefore, *Clarias gariepinus* mean body weight of 600-800g can ovulate and spawn successfully using any of these hormones. Ovaspec as a new hormone is recommended based on the result observed in the present investigation on reproduction and the cost effectiveness.

References

- Adewolu, M. A. and A. J. Adoti, (2010). Effect of mixed feeding schedules with varying dietary crude protein levels on the Growth and feed utilization of *Clarias gariepinus* (Burchell, 1822) fingerlings. *Journal of fishery and Aquatic Science* 5: 304-310.
- Adewumi, A. A., Olaleye, V. F. (2011). Catfish culture in Nigeria: Progress, Prospects and Problems. *African Journal of Agricultural Research*; 6(6):1281-1285.
- Ayinla, O. A., Kayode, O., Idoniboye-Obu, O. I. E., Oresegun, A. and Adidu, V. E. (1994) Use of tadpole meal as substitute for fish meal in the diet of *H. bidorsalis* (Geoffrey St Hillarie 1809). *J. Aqua. Trop.* **9(I)**: 25-33.
- de Graaf, G and Janssen J. (1996). Artificial Reproduction and pond rearing of the African catfish *Clarias gariepinus* in sub-saharan Africa. Rome: FAO Fisheries Technical Paper No. 362.
- Delince G.A, Campbell D, Janssen J.A and Kutty M.N. (1987). *Seed production* (Vol. ARAC/87/WP/13). Port Harcourt, Nigeria, Nigeria: African Regional Aquaculture Centre.
- FAO (2012). The State of World Fisheries and Aquaculture 2012. FAO-Food and Agriculture Organization of the United Nation 00153, Rome, Italy, 230 pp.
- FAO, (2000). Aquaculture newsletter April 2000; 24 – 37.
- Gbemisola, O. B and Adebayo, O. T. (2014). Sperm quality and reproductive performance of male *Clarias gariepinus* induced with synthetic hormones (ovatide and ovaprim). *International Journal of Fisheries and Aquaculture*; 6(1):9-15.
- Hogendoorn, H. and Vismanas, M.M., (1980). Controlled propagation of the African catfish *Clarias lazera* (C and V). II. Artificial reproduction. *Aquaculture*, 21:39-53.

- Madu, C. T. (2006). The effects of brood stock size on the economy of catfish (*Clarias anguillaris*) fry production using the hormone induced natural breeding technique. *Journal of Aquatic Science* 21: 19-22.
- Megbowon I, Fashina-Bombata H.A, Akinwale M.M.A, Hammed A.M, Okunade O.A and Mojekwu T.O. (2013). Breeding performance of *Clarias gariepinus* obtained from Nigerian waters. *IOSR J. Agric. and Vet. Sci.*;6(3):6-9.
- Mudnakudu, C., Nana-deesha, Kondapalii, G.p Rama, N.J Nick C. P and Handady P.C Shetty (1990) Induced Spawning of Indian Mirror Carps through Single application of Ovaprim-C. in the second Asian Fisheries Forum Proceedings of the Second Asian Fisheries Forum. Tokyo, Japan, 17-22 April 1989 pp. 990.
- Ngueku, B. B. (2015). The efficacy of synthetic and non-synthetic hormones in the induced spawning of the African Catfish (*Clarias gariepinus* Burchell, 1822). *International Journal of Fisheries and Aquatic Studies* 3: 34-37.
- Piper, R. G. et al., (1989). *Fish Hatchery Management*. United States Department of the interior, Fish and Wildlife Service.
- Sharma, K., N.K.Yadara, and M.Jindal.(2010). Effects of different doses of overtide on the breeding performance of *Clarias batrachus* Linn. *Livestock Research for Rural Development*. 22 (4) Notes to Authors. www.Irrd.org/Irrd22/4/shar22069htm..Oct ,2011.
- Shinkafi, B. A and Ilesanmi, B. D. (2014). Effect of varying doses of ovatide on the breeding performance of African catfish (*Clarias gariepinus* Burchell, 1822) in Sokoto, North western Nigeria. *Asian Journal of Animal Sciences*, 8(2):56-64.
- Viveen, W. J. A. R., Ritcher, C. J. J., Van Oordt, P. G. W. J., Janseen, J. A. L., and Huisman, E. A. (1985). *Practical manual for the culture of the African Catfish Clarias gariepinus*. Section for Research and Development Co-operation. The Hague, Netherlands, 121.
- Yeldan, H, Avsar, D. (2000). A preliminary study on the reproduction of the rabbit fish *Siganusrivulatus* (Forsskal. 1775) in the North eastern Mediterranean. *Tur. J of Zool*. 24:173-182.

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The Roles of Biotechnology in Fish Nutrition for Sustainable Aquaculture Production in Nigeria

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Abstract

Global aquaculture production has increased continuously over the last decades, and particularly in developing countries such as Nigeria. In recent years, aquaculture has become one of the fastest growing and most efficient food producing ventures in Agricultural-sector all over the world. However, aquaculture industry is presently being confronted with high cost of feeds, which has resulted in low aquaculture output. A phenomenon where the cost of feed ingredients and other inputs are increasing, while market costs for the major cultivable finfish and shellfish species have remained static or are decreasing. Hence, the use of biotechnologically improved products and appropriate use of locally available feed ingredients in aquaculture is highly imperative.. Biotechnology is one tool that holds much promise towards addressing these aquacultural problems. This paper therefore reviews the roles of biotechnology in fish nutrition, with the aim of producing cost effective, nutritionally balanced and environmental friendly fish feed for the sustainability of aquaculture industries in Nigeria.

Key words: Aquaculture, Biotechnology, Fish, Feed

Introduction

Aquaculture can be described as the farming of aquatic organisms such as fish, crustaceans, molluscs and aquatic plants in a controlled and regulated environments. Aquaculture is one of the fastest growing food sector in the world with its increasing role in the economic development and safe food strategy of countries across the world (FAO, 2018). Recently in Nigeria aquaculture sector is faced with several challenges such as high cost of feed, low productivity, low diversification of species, high competition in the market and environmental impacts that have resulted from the intensification and global development of aquaculture industry.

The cost of feed ingredients and other inputs are increasing, while market costs for the major cultivable finfish and shellfish species have remained static or are decreasing. It is, therefore, likely that increased aquaculture production will be from herbivorous/omnivorous fishes in developing countries such as Nigeria and other parts of the world. Aquaculturist can reduce the current dependence on natural marine resource to farm carnivorous finfish and shellfish through the use of the use of biotechnology (Hasan, 2001). As the use of biotechnologically improved products and appropriate use of locally available feed ingredients in semi intensive aquaculture is highly imperative. Biotechnology is one tool that holds much promise towards addressing these aquacultural problems. The relatively new tools of biotechnology offer significant opportunities to improve aquacultural productivity and environmental quality worldwide. This paper therefore reviews the roles of biotechnology in fish nutrition, with the aim of producing cost effective, nutritionally balanced and environmental friendly fish feed for the sustainability of aquaculture industries in Nigeria.

Importance of Nutrition in Aquaculture

The main goal of fish nutrition as a scientific discipline is to produce feeds that support good growth rates while maintaining fish health and quality, resulting in a safe and healthy product for the consumer at least cost. In this regard many scientists are studying the safe utilization of nutrients and their interactions when alternative feed ingredients from plants are used to substitute for traditional (and expensive) fish meal and oil, as well as evaluating alternative marine ingredients (FAO, 2016). The aquaculture feed sector in Nigeria has made tremendous developments during the last two decades. At present about 20 million tonnes of manufactured aqua feed are being used in aquaculture sector, of which the majority is consumed in catfish culture (FAO, 2015). If the rapid growth of aquaculture persists, the feed requirement may increase many fold. Hence, more scientific understanding and interventions are required for sustainable aquaculture of the country. Sustainable commercial fish feed production has become a challenge to the aquaculture nutritionists.

Moreover, Jamu and Ayinla (2003) reported that feed accounts for at least 60% of the total cost of fish production in Nigeria, which to a large extent determines the viability and profitability of fish farming enterprise. As aquaculture becomes intensive, most farmers in Nigeria depend largely on imported fish feed from European countries for the productivity and sustainability of the industry. For example, in Nigeria an estimated 100,000 tons of quality fish feeds are imported into the country each year (Faturoti, 2010, Fasakin, 2011). This has contributed in no small way in increasing the total cost of production which will ultimately translate to high cost of fish, thereby making it expensive for the teeming population of the poor people living in different parts of the country (Akinrotimi et al., 2018). Hence, research in fish nutrition that will utilize locally available ingredients and fabricated equipment without reducing the quality of the feed is urgent and crucial to the overall success of aquaculture development, growth and expansion in Nigeria. Nutrition and feeding play a pivotal role in sustainable aquaculture and since feed constitutes about 40-70% of total cost of aquaculture production. Use of nutritionally balanced and complete formulated feed will continue to play a dominant role in fin fish and shell fish production. Hence, alternative and biotechnologically improved feed ingredients should be sought along with improvements in pond management and manipulation of pond productivity. Into the water can cause problems such as eutrophication or excess algae growth (Emerson, 2011).

Use of Biotechnology in Fish Nutrition

It has been estimated that a feed with FCR 1.2 to 1.3 could make a commercial catfish feed sustainable. Exploration of novel genes related to growth enhancement and use of different nutraceuticals have raised the hope of achieving that target. Isolating a potential growth hormone gene and subsequent transfer of that gene to enhance the fish production is approaching near to reality. Addition of new immuno-stimulants in aqua feed has increased the possibility of safer production through high-tech aquaculture. Strategies for increasing utilization of cheaper nutrients like carbohydrate by various technological interventions and addition of feed attractants paved the way for developing lower cost feeds sustainable catfish culture (FAO, 2013).

Roles of Biotechnology Fish Nutrition

The goal of any feed producer is to produce a balanced aqua feed that is nutritionally balanced, cost effective, and environmental friendly

1. Manipulation of Plant-genome

One of the most exciting technological developments has come from the ability to manipulate the plant genome to produce products economically for use in aquaculture. The use of genetically modified crops to eliminate anti-nutritional factors and increase specific nutrients (limiting amino acids, n-3 fatty acids, etc.) is now possible. The packaging of genetically engineered proteins in corn seed to produce very inexpensive oal vaccines is also being pursued (FAO, 2017).

2. Use of Plant Fibres in Fish Feed Through Application of Enzymes

Applications of enzymes have been in use for a long time in industrial applications in production of detergents, textiles, confectioneries and alcoholic drinks, their use in fish feed is a recent phenomenon. This is because enzymes need to be designed to suit the appropriate application (Kowtal, 2007). Industrial enzymes are mainly produced from microorganisms by a process of fermentation and extraction. These enzymes can be produced in large quantities from genetically modified microbes with desired properties to make them economically viable.(Rex, 2015). Many alternative feed sources such as sunflower, can provide protein, and sorghum, millets or rice bran for energy could be used as feed ingredients if supplemented by substrate-specific enzymes. Cell wall composition of these high fibers feed ingredients show that they contain large amounts of arabino-xylans, pectic polysaccharides and some cellulose.

Use of specific enzymes like xylanase, pectinase and cellulase could allow breakdown of the fibre releasing energy as well as increasing the protein digestibility due to better accessibility of the protein (Penman, 1999). In this way the feed cost could be reduced and the protein levels in the feed a increased. The scope for increasing the use of enzymes in the coming decade is certainly there when high quality enzymes become available with more predictable performances. One of the common enzymes that could be use is phytase. Phytase reduces the use of expensive supplemental inorganic phosphorus such as dicalcium phosphate. Phytase releases minerals (Ca, Mg, Zn and K), amino acids and proteins, which are complexed with the phytate molecule. Phytate itself is an anti-nutritive factor, which when hydrolysed gives better performance in animals (Subasinghe 2007).

3. **Nutraceuticals**

Nutraceutical implies that the extract of food is demonstrated to have a physiological benefit or provide protection against a disease and/or improve growth. Functional foods are defined as being consumed as part of a usual diet but are demonstrated to have physiological benefits and/or reduce the risk of disease beyond basic nutritional functions. Nutraceuticals are often used in nutrient premixes or nutrient systems in the food. In aquaculture, application of nutraceuticals includes addition of feed additives in feed such as antioxidants, vitamins, minerals, and carotenoids etc (Tepifer, 2002). Nutraceuticals are also extracted from many fishes including omega-3 oil, chitosan and glucosamine, originally derived from waste products. Hundreds of tons of marine by-products are available annually which are driving force for both research and commercialization in the area of marine nutraceuticals.

4. **Production of Dietary amino acids through GMOs**

Essential amino acids are added as supplements to the feed improve the balance of the amino acid profile. Since the amino acid profiles of feed ingredients do not normally match the profile of amino acid requirements of the target species, supplemental essential amino acids are added to improve protein utilisation. The new trend is to formulate diets on digestible amino acid levels thereby reducing the requirement for protein. So far lysine and methionine have been used as supplements. Lysine is produced by microbial fermentation and methionine is chemically synthesized. Genetically enhanced micro-organisms are being used to produce threonine and tryptophan on a commercial basis and soon other essential amino acids also would become available. Using all these amino acids it is possible to lower dietary crude protein level by 2 – 3 %, which is a substantial saving for the farmer. The concept of an ideal protein blend from GM feedstuffs and feed additives (such as amino acids and enzymes) will greatly help with decreasing the amount of nitrogen excreted in animal waste (Reyes and Fermin, 2003).

5. **Toxin binders In Fish Feed**

Feed manufacturers have been incorporating various mold inhibitors in their diets to prevent mycotoxin formation. A variety of physical, chemical and biological approaches to counteract the mycotoxin problem have been reported, but large scale, practical and cost effective means for detoxification of mycotoxins containing feed stuffs are limited. Most of them are fungistats and not fungicides that only inhibit growth of molds and do not inactivate any toxins already present (Mair, 2011). In the future, biotechnology based products like microbes, herbal extracts or esterified glucomannan could be used

6. **Fish feed attractants**

Colour, smell, odour, taste and flavour of several food and feed stuffs play an important role in attraction of animals towards a particular feed (Soltanian *et al.*, 2009). New strategies including from the Central Institute for Fisheries Education, Mumbai, are being adopted to isolate, purify and utilize the various active principles and chemical ingredients from indigenous plants and traditional herbs as fish attractants in feed. This may help in reducing feed waste and scheduling of feeding frequency.

7. **Probiotics in fish nutrition**

Microorganisms are naturally present in the digestive system of the animals. Some microbes aid digestion, others can potentially cause pathogenesis. The microbial ecology of the gut merits greater attention due to its implications for nutrition, feed conversion and disease control. Use of antibiotics disturbs the microbiological balance of gut flora eliminating most of the beneficial flora. On stopping antibiotic treatment, pathogens begin to reestablish themselves in the intestine. Overgrowth of these organisms and subsequent invasion of the system by pathogenic organisms cause inflammatory, immunological, neurological and endocrinological problems. Using probiotics can help build up the beneficial bacteria in the intestine and competitively exclude the pathogenic bacteria (Gatesoupe 1999). Hence usage of probiotics is propagated to counter the effect of viral and bacterial infections in commercial aquaculture.

8. **Prebiotics in Fish Nutrition**

The concept of prebiotics in aquafeed is fairly recent. Prebiotics are basically feed for probiotics that are resistant to attack by endogenous enzymes and hence reach the site for proliferation of gut microflora. Some of the prebiotics that are currently used in animal feed are mannan-oligosaccharides (MOS), fructo-oligosaccharide and mixed oligo-dextran.

9. Genetic manipulation in bacterial biofilms - a source for fish nutrition

Molecular approaches to characterizing biofilm structure and development offer considerable potential for finding novel biofouling and disease prevention strategies in enhancing aquatic productivity. It is now possible to determine the genes and pathways involved in regulation and synthesis of bacterial adhesive polymers and virulence antigens. Considerable progress has been made in understanding the nature and expression of surface polymers and bacterial vaccines produced by microorganisms such as the nitrogen-fixing *Rhizobium* species and the opportunistic pathogen *Pseudomonas aeruginosa* etc. Similar approaches can be applied to marine biofilm bacteria, to find the genetic determinants of adhesive production and the environmental factors that regulate synthesis (Harwood and Gibson, 1988).

10. Nutrigenomics

Nutrigenomics is the study of molecular relationships between nutrition and the response of genes, with the aim of extrapolating how such subtle changes can affect animal health. Nutrigenomics focuses on the effect of nutrients on the genome, proteome, and metabolome. It is applying the sciences of genomics, transcriptomics, proteomics and metabolomics to animal nutrition in order to understand the relationship between nutrition and health. Nutrigenomics has also been defined as the application of high-throughput genomic tools in nutrition research (Changadeya *et al.*, 2003). This refers to genetic tools that enable literally millions of genetic screening tests to be conducted at a single time. When such high throughput screening is applied in nutrition research, it allows the examination of how nutrients affect the thousands of genes present in the animal genome. Nutrigenomics involves the characterization of gene products and the physiological function and interactions of these products. This includes how nutrients impact on the production and action of specific gene products and how these proteins in turn affect the response to nutrients. Nutrigenomics has been associated with the idea of personalized nutrition based on genotype. While there is hope that nutrigenomics will ultimately enable such personalised dietary advice, it is a science still in its infancy.

Conclusion

Aquacultural practices in Nigeria are gaining more and more grounds in different parts of the country especially among the rural populace. Furthermore, rooms exist for increasing aquaculture production through better farm management, genetics, tested techniques and innovations. But meeting the ever increasing demand for fish in Nigeria through aquaculture will have to come from the use of locally produced cost effective fish feed that will increase aquaculture production and make it attractive to all and sundry especially, the majority of poor people living in the country. It is hoped that biotechnology will play a promising role in the fish nutrition in future. One day, genes that enable fish to digest and utilize nutritionally poor feedstuffs will be transferred. Once this is accomplished fish will be able to utilize chitin and will be able to efficiently utilize poor sources of protein such as chicken feathers. This will lower feed and production cost

References

- Adelizi, P. (1998). Agbiotech Information Bulletin for Schools. Issue 33. Published by AG-WEST BIOTECH INC. Sask., S7N 3R2 Canada.
- Changadeya W. Malekano L.B and Ambali A.J.D (2003). Potential of genetics for aquaculture development in Africa. *NAGA* 26: 31-35
- CIFA (1998): A strategic reassessment of fish farming potential in Africa. *CIFA Technical Paper* 32; 1-15.
- El-zaeems, S.Y. (2004). Alteration of the productive performance characteristics of Lysozyme transgenic Atlantic salmon (*Salmo salar* L.). *Aquaculture Research*, 42: 427–440.
- Emerson, P. (2011) Biotechnology and Religion. Ezine Articles. Retrieved for [http://www.ezinearticle.com/Biotechnology and Religionsid =354558S](http://www.ezinearticle.com/Biotechnology%20and%20Religion%20=354558S)
- FAO (2008): Aquaculture development. 5. Genetic resources management. FAO Technical Guidelines for Responsible Fisheries. No. 5, Suppl. 3. Rome, FAO.2008.125p.
- FAO (Food and Agriculture Organization) (2015). Fisheries Topics: Technology. Biotechnology. Text by Deevin Bartley and Rohana Subasinghe. In: FAO Fisheries and Aquaculture Department (online). Rome. Updated 27th May 2005. <http://www.fao.org/fishery/topic/12316/en>.
- FAO (Food and Agriculture Organization). (2013). Assessment and Management of Seafood Safety and quality. FAO Technical Paper Fisheries. No. 444 Rome, FAO. 2003.230p
- FAO (Food and Agriculture Organization). (2016). The State of World Fisheries and Aquaculture FAO, Rome, Italy.

- FAO. (2010). The State of World Fisheries and Aquaculture. Rome. 197 pp.
- FAO. (2017). The role of aquaculture in sustainable development. Thirty-fourth Session. 17-24
- Fasakin, E. A. (2001) Application of linear programming to least-cost feed formulation for warm water fish species P. 26-29. In: A. A. Eyo (ed) Proceeding of the first national symposium on fish Nutrition and Feed Technology held in Nigeria Institute for Marine and Oceanography Research (NIOMR), Lagos. 26-29 Oct. 1999.
- Faturoti, E. O. (2000). Beneath the Ripples and Sustainable fish production. Inaugural Lecture, University of Ibadan, Ibadan. pp:50-54.
- Hassan, M. R.; Moniruzzamai, M and Omar, A. M. F. (1990) Evaluation of leveaena and waterlyacynth leaf meal as dietary protein sources of the fry of Indian major carp labeo rohita (Hamittan). The secone Asian fisheries forum. Asian Fisheries society manilla, phillipines. 999pp.
- Hew, C.L., Fletcher, G.L. 2001. The role of aquatic biotechnology in aquaculture. *Aquaculture* 197, 191-204.
- Jamu D.M and Ayinla O.A (2003). Potential for the development of aquaculture in Africa NAGA 26:9-13.
- Kowtal, G. V. (2007) Preliminary experiments in induction of polyploidy, gynogenesis and androgenesis in the white. Sturgeon, Acipenser Engineering in Aquaculture. *Journal of the World Aquaculture Society*; 26(2):132-142
- Mair, G.C. (2001b) Tilapia Genetics in Asia. Sixth Central American Aquaculture Symposium. Proceedings Tilapia session (ed. D.E. Meyer) PD/A CRSP, Tegucigalpa, Honduras. Pp.9-34.
- Mair, G.C. (2002). Tilapia Genetics and Breeding in Asia. In: Guerrero III, R.D. and M.R. Guerrero-del Custillo (eds.) Tilapia farming in the 21st Century. Proceedings of the International Forum on Tilapia Farming in the 21st Century (Tilapia forum, 2002) 1845p. Phillipine Fisheries Association, Inc., Losbanos, Laguna, Philippines. P. 100-123.
- Penman, D. J (1999): Biotechnology and aquatic genetics resources. Genes and genetically modified organism. In R.S.V. Pullin, D.M. Barthy and J. Kooiman (eds) Towards policies for conservation and sustainable use of aquatic genetic resources ICLARM. *Conf. Proc.* pp.23-33
- Rex, A.D. (1995). The contribution of genetically improved aquatic organism to global food security. International Conference on sustainable contribution of Fisheries to Food Security, in collaboration with FAO. pp24
- Reyes O.S and Fermin A.C (2003): Terrestrial leaf meals or fresh water aquatic fern as potential feed ingredients for farmed a balon Haliotis asinine (Linnaeus 1758). *Aquaculture Research* 34:6-12.
- Soltanian, S., Stuyven, E., Cox, E., Sorgeloos, P., Bossier, P. 2009. Beta-glucans as immunostimulant in vertebrates and invertebrates. *Critical Reviews in Microbiology* , 35: 109–138.
- Subasinghe, R.P. 2007. Aquaculture: Status and Prospects. In —Role of Aquaculture in Sustainable Development. FAO Department of Fisheries and Aquaculture, Rome, Italy.
- Tepfer, M. 2002. Risk assessment of virus-resistant transgenic plants. *Annual Review of Mol Mar Biol Biotechnol.* 1(4-5):309-17.

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Applications of Environmental Biotechnology for Sustainable Aquaculture Production in Nigeria**Akinrotimi O. A., Edun O. M., Okenwa, U. and Iteze P.**

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Abstract

This paper reviewed the possibility of environmental biotechnology techniques utilization in aquaculture and reviews its various aspects that could be of utmost importance in aquaculture practises. Biotechnology has played important roles in boosting production in the aquaculture sector for several years. Considering the number of issue that are associated with ecological integrity in an aquaculture systems, the field of environmental biotechnology has shown new possibilities to operate environmental friendly aquaculture. Since the environment turns to be a vital section in the survival and sustainability of aquatic organisms, its day by day deterioration through pollution and toxic substances need to be controlled. The distinct role of environmental biotechnology within the sector of aquaculture emphasized finding the opportunities to contribute with new solutions and directions in remediating the contaminated environments, minimizing future waste release and creating pollution prevention alternatives for the sustainability of aquaculture industry.

Keywords: Aquaculture, Biotechnology, Environment, Fish**Introduction**

Aquaculture can be described as the systematic farming of aquatic organisms such as fish, crustaceans, molluscs and aquatic plants under controlled environmental conditions (Akinrotimi *et al.*, 2011a). Aquaculture is the fastest growing food producing sector in the world with its increasing role in the economic development and food security strategy of many nations especially the developing countries across the world (FAO, 2010). In recent years, aquaculture sector in Nigeria is confronted with a number of challenges such as high cost of aqua feed, low diversification of species, high competition in the market and environmental impacts that have resulted from the intensification and global development of aquaculture industry (FAO, 2015). Biotechnology is one tool that holds much promise towards addressing these aquacultural problems. The relatively new tools of biotechnology offer significant opportunities to improve aquacultural productivity and environmental quality worldwide (Cantor, 2000). All of these contribute to increase the intensity and produce more products at less economic and environmental cost, thereby helping to build global food security and more sustainable and environmentally friendly farming (FAO, 2015).

Environmental biotechnology is concerned with the application of biotechnology as an emerging technology in the context of environmental protection, since rapid industrialization, urbanization and other developments have resulted in a threatened clean environment and depleted natural resources (Ah-You *et al.*, 2000). It is not a new area of interest, because some of the issues of concern are familiar examples of “old” technologies, such as: composting, wastewater treatment etc. In its early stage, environmental biotechnology has evolved from chemical engineering, but later, other disciplines (biochemistry, environmental engineering, environmental microbiology, molecular biology, ecology) also contribute to environmental biotechnology development (Andres *et al.*, 2006). However, Araik (2006), enumerated vividly that environmental biotechnology refers to the utilization of microorganisms to improve environmental quality. Although the field of environmental biotechnology has been around for decades, starting with the activated sludge and anaerobic digestion in the early 20th century, the introduction of new technologies from modern microbiology and molecular biology has enabled engineers and scientists to tackle the more contemporary environment problems such as detoxification of hazardous wastes through the use of living organisms.

Concept of Sustainable Development in Aquaculture

Emerging aquaculture production systems have a significant potential to curb the global food security problems and to meet human nutritional needs with improved environmental performance. Aquaculture sector comprising of a wide range of culture practices of various species starting from finfishes, crustaceans, seaweeds, molluscs, and other

aquatic organisms (SOFIA, 2018). Because of this aquaculture sector is opening up the windows of opportunities for urban as well as rural areas in their socio-economic developments. But as the aquaculture industry expanding, the sector is also facing some problems like environmental degradation, water scarcity, limited availability of land for aquaculture, high input costs etc (FAO, 2007). So, sustainability in the aquaculture sector is the need of the hour.

Even though living resources are self-renewable, the focus needs to be on sustainability before resource utilization. Sustainable development focuses on the management and conservation of natural resources and the orientation of technological and institutional changes in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development in fisheries and aquaculture sectors conserves land, water, plant, and animal resources are environmentally non-degrading, technically appropriate, economically viable, and socially acceptable. (FAO,1995).

Therefore, Sustainable aquaculture can be defined as the aquaculture practice which focuses on environmental, economic, and social sustainability to improve capacity building and utilize land effectively for the aquaculture sector. Sustainability of aquaculture must be in three ways: environmental, economic and social sustainable. Environmental sustainability means aquaculture practice should be eco-friendly. It should not impose any significant disruption to aquatic biodiversity. While, in economic sustainability, the aquaculture practice should be profitable with a good and long-term prospects. In Social sustainability, aquaculture practice must be socially responsible and contribute to the wellbeing of the local community(Subasinghe, 2007; Subasinghe et al., 2009).

Roles of Biotechnology in Improving Environments in Aquaculture

Biotechnology, has been described as the utilization of biological systems or living organisms in the production process, according to FAO (20015), it has a wide range of useful applications in fisheries and aquaculture. It has the capacity to improve the environmental situations in aquacultural practises. Through detection with the aid of biosensors and biomonitoring. Also, to control and to remediate the emission of pollutants into the environment by ensuring the degradation of harmful substances during water/wastewater treatment, soil decontamination, treatment and management of solid waste (Conti, 2007).

Environmental biotechnology can also contribute to pollution reduction are the production of biomolecules (proteins, fats, carbohydrates, lipids, vitamins, amino acids), yield improvement. The production processes can assist in the reduction of waste and minimization of pollution by the so-called clean technologies with biotechnological tools involved in reuse or recycles waste streams, generate energy sources, or produce new, viable products (Cantor, 2000).

Bioremediation

Bioremediation techniques are known to be an environment-friendly, healthy, efficient and cost-effective in improving the quality of aquaculture by minimizing waste and reducing environmental damage. Bioremediation, as defined by U.S. Environmental Protection Agency (USEPA) is “a managed or spontaneous practice in which microbiological processes are used to degrade or transform contaminants to less toxic or nontoxic forms, thereby remediating or eliminating environmental contamination” (FAO, 2007). The primary principle is to biologically degrade the organic waste, under controlled conditions into an innocuous state or to the levels below concentration limits. As bioremediation is feasible only in manipulated environmental conditions which permit microbial growth. The presences of nutrient fertilizers such as nitrogen and phosphorus, as well as oxygen, boost the capability of the microorganism of breaking down the organic pollutant. Aerobic bacteria responsible for oxidizing processes can only function well in an ample amount of oxygen. The utilization of macro and microorganisms and their products as additives to enhance water quality is known to be as bioremediation or bioremediating agents (Ahn *et al.*, 2005).

Wastewater Biotreatment

Water is the most basic and most essential compound of all living processes in our water planet (Biswas and Maurye, 2017). Despite many attempts to stop the destruction and pollution of water resources, humans’ impact on the natural cycle of water make irreparable risks in this area and it requires a consideration on the necessity of the use of new methods to prevent contamination of water resources (Durrieu *et al.*, 2000). Wastewater compounds may be physical, chemical or biological, and cause environmental impacts including changes in aquatic habitat and its special structure, and the change in biodiversity and water quality (Badiola *et al.*, 2012). Three basic groups of biological processes in aquatic environments include aerobic processes, anaerobic processes or a combination of both of them (Biswas and Maurye, 2017). The main objectives of wastewater treatment processes can include:

Reduction of biodegradable organic content (BOD₅) Removal of toxic and heavy metals, removal or reduction of nitrogen and phosphorus-containing compounds Removal or reduction of nitrogen and phosphorus-containing compounds Removal or inactivation of pathogenic microorganisms and particles (USEPA, 2004).

Biosorption

Biosorption is a fast and reversible process for the removal of toxic metal ions from wastewater by live or dried biomass, which resembles adsorption and in some cases ion exchange (Gavrilescu 2009). The biosorption is an alternative measure for remediation of industrial effluents as well as the recovery of metals. Biosorbents are prepared from naturally abundant and waste biomass. It has been demonstrated that both living and non-living biomass may be utilized in biosorption processes, as they often exhibit a marked tolerance towards metals and other adverse conditions (Gavrilescu 2009). Biosorption of heavy metals by algal biomass is an appropriate and economically feasible method used for wastewater and waste clean-up, as it uses algal biomass which is waste from biotechnological processes (Feng and Aldrich 2004) or its availability in coastal areas makes it suitable for developing new by-products for wastewater treatment plants (Brinza *et al.* 2007).

Biofilters

Biofilters or biological filters allow the diffusion of oxygen and form adhesion sites for rapidly collecting natural aerobic bacteria involved in the nitrification and denitrification processes (Rijn 1996). According to Saidu (2009), biofilters are generally classified into two categories of emerged and submerged. In the emerged biofilters, the water cascades over the media to maximize the transfer of oxygen, by providing optimal conditions for efficient nitrification. The submerged biofilters are entirely in the bulk media and consist of a packing, liquid and biofilm phases. Biofilters are commonly used in semi-closed recirculating systems to treat aquaculture wastewater to be reused. The recirculating methods involve recirculating water between a culture facility and a water-treatment facility containing the biofilter. The waste is captured in concentrated effluents; it is thickened to sludge and then decomposed by the bacteria present in the biofilter (Rijn 2013). Badiola *et al.* (2012) reported that biofilters have an efficiency of reducing waste up to 90%. The most commonly used type of biofilters includes: microbial mats, activated sludge, trickling filter, rotating biological contactor and denitrifying screens.

Bioaugmentation

Bioaugmentation involves either addition of commercially prepared bacteria strains or addition of a blend of isolated enzymes or the combination of both the bacteria strains and the proteins (mostly preferred), which increase the natural degradation carried out by the indigenous bacterial population. Bacteria strains (most preferably indigenous ones) are carefully isolated, tested and applied as bioremediation agents. Presently, biotechnology uses some bacterial strains that have been genetically modified to increase their stability and survival in the aquatic environment. The most commonly used and commercially available augmenting agents belong to the genus *Bacillus* (mostly preferred due to its ability to secrete many different enzymes), which helps in mineralization and breakdown of proteins. The earliest documentation on the use of bioremediation in aquaculture described the use of different strains of *Bacillus* spp. in a *Penaeus monodon* farm (Porubcan 1991). In this experiment, bacteria were first pre-inoculated into the rearing water, which diminished the concentrations of the ammonia and nitrite, and then increased the shrimp survival.

Environmental Biotechnology Monitoring

Environmental monitoring deals with the assessment of ecological quality, primarily by measuring a set of selected parameters regularly. In general, two methods - physicochemical and biological - are available for measuring and quantifying the extent of pollution (Conti, 2007). The harmful effect of toxic chemicals on natural ecosystems has resulted in an increasing demand for early-warning systems so on detect those toxicants at deficient concentrations levels (Durrieu *et al.* 2006). The integration of environmental biotechnology with information technology has revolutionized the capacity to monitor and control at molecular levels (Bitton, 2005).

Bioindicators/Biomarkers

Most recently, environmental monitoring programmes have included the determination of contaminant levels in biota, along with the assessment of various responses of biological/ ecological systems. Some organisms or communities may react to an environmental effect by responding in a measurable changed biological function and their chemical composition. This significant environmental change and their responses are referred to as bioindicators/biomarkers (Conti 2007). Three main types of indications can be obtained: on exposure, effect, and susceptibility. Biomarkers that have the potential for use in biomonitoring are: molecular (gene expression, DNA

integrity), biochemical (enzymatic, specific proteins or indicator compounds), histo-cytopathological (cytological, histopathological), physiological and behavioural.

Biosensors

Research on biosensing techniques and devices for aquaculture, together with that in genetic engineering for sensor cell development has expanded in the latest time. Environmental biosensors are analytical devices composed of a biological sensing element or biomarker (enzyme, receptor antibody or DNA) in intimate contact with a physical transducer (optical, mass or electrochemical), which together relate the concentration of an analyte to a measurable electrical signal (Rodríguez-Mozaz *et al.* 2004). The biosensors exploit biological specificity to supply signals which will be wont to measure pollution levels. Biosensors based on a combination of a biological sensing element and an electronic signaltransducing element that offer high selectivity, high sensitivity, short response time, portability and low cost, are ideal for monitoring pollutants in the environment of an aquaculture system (Lam and Gray 2003).

Conclusion

The issues of environmental challenges in aquaculture practises, has been on the rise in recent years, due to increase volume of output in fish farming. There is the need for new approaches to control the environmental challenges. However, technologies for environmental protection and controls in aquaculture system are currently in infancy. Though new approaches continue to gain more and more ground in practice, harnessing the potential of bioremediation, enzyme engineering for improved biodegradation, evolutionary and genomic approaches to biodegradation, designing strains for enhanced biodegradation, reuse of treated wastewater, biomembrane reactor technology and design wastewater treatment based on decentralized sanitation and reuse. Since environmental biotechnology proved to have an enormous potential to contribute to the prevention, detection and remediation of environmental pollution and degradation, it is a sustainable way to develop clean processes and products, less harmful, with the reduced environmental impact on the different production systems in aquaculture.

References

- Ahn Y, Jung H, Tatavarty R, Choi H, Yang J, Kim IS (2005) Monitoring of petroleum hydrocarbon degradative potential of indigenous microorganisms in ozonated soil. *Biodegradation* 16, 45-56
- Ah-You K, Suleiman M, Jaworski J (2000) *Biotechnology and Cleaner Production in Canada*. Program for Energy Research and Development (PERD), Life Sciences Branch Industry Canada, Ottawa, 96 pp.
- Akinrotimi, O.A. Cliffe, P.T., & Ibemere, I.F. (2011a). Integration of rural aquaculture into small scale farming in Niger Delta region of Nigeria. *Global Approaches to Extension Practice*, 7(1), 43-48
- Akinrotimi, O.A., Abu, O.M.G., & Aranyo, A.A. (2011b). Transforming aquaculture from subsistence to commercial level for sustainable development in Niger Delta Region of Nigeria. *Journal of Agriculture and Social Research*, 11(2), 22 – 33.
- Andres Y, Dumont E, Le Cloirec P, Ramirez-Lopez E (2006) Wood bark as packing material in a biofilter used for air treatment. *Environmental Technology* 27, 1297-1301.
- Arai K (2006) Toward biotechnology: The mission of IUBMB in the 21st century. *IUBMB Life* 58, 267-268
- Badiola, M., Mendiola, D. and Bostock, J. 2012. Recirculating Aquaculture Systems (RAS) analysis: Main issues on management and future challenges. *Aquac. Eng.*, 51: 26-35.
- Biswas, J.K. and Maurye, P. 2017. Aquaculture Biotechnology: Prospects and Challenges, *Progress of Biotechnology in India*, pp 33-47.
- Bitton, G. 2005. *Wastewater Microbiology*, Wiley-Liss, John Wiley and Sons, (766 pp) New Jersey, USA.
- Brinza, L., Dring, M.J. and Gavrilescu, M. 2007. Marine micro and macro algal species as biosorbents for heavy metals. *Environ. Eng. Manag. J.*, 6: 237-251.
- Cantor, C.R. 2000. Biotechnology in the 21st century. *Trends Biotechnol.*, 18: 6-7.
- Conti, M.E. 2007. *Biological Monitoring; Theory and Applications, Bioindicators and Biomarkers for Environmental Quality and Human Exposure Assessment*, WIT Press, Southampton, UK, 228.
- Durrieu, C., Tran-Minh, C., Chovelon, J.M., Barthet, L., Chouteau, C. and Védrine, C. 2000. Algal biosensors for aquatic ecosystems monitoring. *Eur. Phys. J. Appl. Phys.*, 36: 205-209.
- FAO (Food and Agriculture Organization). 2005. Fisheries Topics: Technology. Biotechnology. Text by Devein Bartley and Rohana Subasinghe. *In: FAO Fisheries and Aquaculture Department* (online). Rome. (May 2005).
- FAO. 2007. The role of aquaculture in sustainable development. Thirty-fourth Session. 17-24 November 2007, C 2007/INF/16 Rome. FAO. 10 pp.

- FAO. 2010. The State of World Fisheries and Aquaculture. Rome. 197 pp.
- Fletcher, G. L., Hobbs, R. S., Evans, R. P., Shears, M. A., Hahn, A. L., Hew, C. L. 2011. Lysozyme transgenic Atlantic salmon (*Salmo salar* L.). *Aquaculture Research*, 42: 427–440.
- Porubcan, R.S. 1991. Reduction in chemical oxygen demand and improvement in *Penaeus monodon* yield in ponds inoculated with aerobic *Bacillus* bacteria. Program and Abstracts of the 22nd Annual Conference and Exposition, San Juan, Puerto Rico. World Aquaculture Society.
- Rijn, J.V. 1996. The potential for integrated biological treatment system in recirculating fish culture—a review. *Aquac.*, 139: 181-201.
- Rijn, J.V. 2013. Waste treatment in recirculating aquaculture systems. *Aquac. Engi.*, 53: 49-56.
- Rodríguez-Mozaz, S., Marco, M.P., López de Alda, M.J., Barceló, D. 2004. Biosensors for environmental applications: Future development trends. *Pure Appl. Chem.*, 76: 723-752.
- SOFIA (State of Fisheries and Aquaculture in the world) 2018. Annual report by FAO, Meeting the sustainable development goals.
- Soltanian, S., Stuyven, E., Cox, E., Sorgeloos, P., Bossier, P. 2009. Beta-glucans as immunostimulant in vertebrates and invertebrates. *Critical Reviews in Microbiology*, 35: 109–138.
- Subasinghe, R., Soto, D., Jia, J. 2009. Global aquaculture and its role in sustainable development. *Reviews in Aquaculture*, 1: 2–9.
- Tepfer, M. 2002. Risk assessment of virus-resistant transgenic plants. *Annual Review of Phytopathology*. 40, 467-491.
- Subasinghe, R.P. 2007. Aquaculture: Status and Prospects. In —Role of Aquaculture in Sustainable Development. FAO Department of Fisheries and Aquaculture, Rome, Italy.
- USEPA. 2004. Assessment and Remediation of Contaminate Sediments (ARCS) Program. Final Summary Report, EPA-905-S-94-001, USEPA, Chicago.

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Studies on the Fertilization, Hatchability, and Survival Rate of *Clarias Gariepinus* Larval Produced Using Ovulin and Ovatide

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Abstract

Studies on the fertilization, hatchability and survival rate of *Clarias gariepinus* larval produced using Ovulin and Ovatide was carried out in Nigerian Institute for Oceanography and marine research, Badore out station. The result reviewed that the percentage fertilization was $80 \pm 20.34\%$ for Ovulin which was higher than 79.60 ± 30.07 recorded for Ovatide, hatchability was 75.31 ± 28.40 for Ovulin and 74.56 ± 22.08 for Ovatide while the survival rate was higher in Ovatide which recorded 45.07 ± 28.29 and Ovulin recorded 40.66 ± 24.77 all in percentage. There was no significant difference in all the parameters investigated. The physic-chemical parameters were within the acceptable range.

Keywords: Fertilization, Hatchability, Survival rate and Hormones

Introduction

The success of any Aquaculture Operation depends on the availability of a steady supply of fish larvae for growing to market size. (Rottmann, *et al.*, 2003). The rearing of the larvae to the fry stage is most important in fish production cycle. This success in seed production also depends largely on production techniques. There are three major techniques through which fish feed can be produced and are as follows:- Natural seed production where the males and females are allowed to reproduce naturally, the semi-natural seed production where both males and females are induced but are allowed to reproduce naturally and the artificial breeding (induced breeding) where the reproduction is achieved artificially. According to FAO, (1996), the output of natural breeding in fish is very low and cannot meet the protein requirement of its consumers. In view of this, an artificial breeding technique under more controlled condition has been discovered to produce reliable success of fish fry and fingerlings (FAO, 1996).

A large number of natural and synthetic spawning agents for induced breeding of the African catfish *C. gariepinus* are available and these include Deoxycorticosterone Acetate (DOCA), Human Chorionic Gonadotropin (HCG) and Pituitary Gland Extract (PGE) (KulwaL, *et al.* 2017) for natural agents. These hormones are known to be used successfully, however they are deficient in various ways, such as Deoxycorticosteroid Acetate (DOCA) causes severe ulcer on the injected female, Human Chronic Gonadotropin (HCG) is expensive (Olaniyi, and Akinbola, 2013), and Pituitary Gland Extract (PGE) is difficult to quantify (Olaniyi, *et al.*, 2005 and Khan, *et al.* 2006.). While the synthetic agent includes gonadotrophin releasing hormone analogues (GnRH-a) which are administered to the female brood stocks (Oyelese, *et al.* 2006). Gonadotropin Releasing Hormone analogue (GnRHa) is now the best available biotechnological tool for the induced breeding of fish. These includes the following which have been used to induce breeding successfully, Ovaprim, Ovatide, Ovaryprim, Ovopel, Ovupin-L, Ovulin, Dagin and Aquaspawn (Ngueku, 2015 and Zhuo, *et al.* 2011). Among Gonadotropin Releasing Hormone analogue (GnRHa), Ovaprim and Ovatide containing salmon gonadotropin releasing hormone analogue and domperidone (SGnRHa + Domperidone) which are usually used for spawning induction in catfishes to get quality seed (Sahoo, *et al.* 2005).

Artificial breeding of *C. gariepinus* is the most promising and reliable way of ensuring large scale production of quality fish seeds throughout the year and sustainability of aquaculture sector. Induced breeding of *C. gariepinus* became very important in addressing unreliable seed supply due to low fertilization, egg hatchability, improper selection of brood fish and use of hormone (Mosha, 2018). This study therefore investigates and compares the hatchability, performance and survival rates of *Clarias gariepinus* larval produced using Ovulin and Ovaprim.

Materials and Methods

Experimental site

The experiment was conducted in Nigerian Institute of Oceanography and Marine Research Badore out Station hatchery. The hatchery is a flow through hatchery with over fifteen rectangular tanks measuring (1x1x0.5) m. The source of water is through bore hole.

Experimental Fish

The total of fifty four (30) brood fish of *C. gariepinus* weighing 0.8kg averagely at the ratio of 12 females to 18 male was purchased from a reputable fish farm in Lagos. They were acclimatized for two weeks and were starved for 24 hours before used for the study.

Hormone Administration

The hormones were administered intramuscularly after which the treated fish were returned back in their vat and were covered tightly. The study was carried out six batches, two gravid female and three matured males were used per batch. The two females were injected with Ovaprim and Ovulin respectively at a dosage of 0.5ml per kg. Three males were scarified and their testes were removed, their milt was squeezed out into saline solution.

One gram of the eggs was measured out and counted repeatedly under a microscope (Adebayo, 2006) for four times and average of 630 eggs for 1g was used for the study. Agbebi *et al.* (2013) reported 600eggs for 1g. The eggs were fertilized and incubated. After 12 hours of incubation, the white eggs were removed with a plastic spoon for each treatment and counted and recorded. Hatching started at 22 hours and concluded at 31 hours. The newly hatched fry escaped through the net into the vat while the unhatched eggs remained on the net. The larvae were fed for four weeks.

To estimate the percentage fertilization, the number of the dead eggs was subtracted from each experimental units and replicates and was used to estimate the percentage fertilization according to Adebayo, (2006).

$$\text{Fertilization rate (\%)} = \text{no of fertilized eggs} / \text{total no of eggs counted} \times 100/1$$

The number of hatchlings in each treatment units were carefully counted and the hatchability was determined using the equation below according to Adebayo, (2006)

$$\text{Hatchability (\%)} = \text{no of hatchlings} / \text{total no of eggs incubated} \times 100/1$$

$$\text{Survival rate (\%)} = \text{no of hatchlings alive to larvae} / \text{total no of hatchlings} \times 100/1 \text{ (Adebayo. 2006)}$$

The physico-chemical parameters were taken before, within and after the study and were recorded.

Results were presented as mean and standard deviation of mean ($\pm$ SD). The data collected were subjected to one way analysis of variance (ANOVA) and level of significance was determined at $p < 0.05$.

Results and Discussion

The data collected from the study were presented in Tables 1 and 2. Table one shows the average weight of the female fish used for the study, the average number of eggs collected, the quantity of hormone (Ovulin and Ovotide) used for the inducement, the latency period and the age of the female and male fish used for the study. While Table 2 shows the percentage fertilization, hatchability, and survival rate of the larvae after four weeks of rearing.

From the results recorded in Table 2, the percentage fertilization was $80 \pm 20.34\%$ was recorded for Ovalin which was higher than 79.60 ± 30.07 recorded for Ovotide, hatchability was 75.31 ± 28.40 for Ovulin and 74.56 ± 22.08 for Ovotide while the survival rate was higher in Ovotide which recorded 45.07 ± 28.29 and Ovulin recorded 40.66 ± 24.77 all in percentage. Nwokoye *et al.*, (2007) reported that Ovaprim (0.4 – 0.5) has been known to give a better result because of its potency and quality, ease handling and better survival of hatchlings. Adebayo, *et al.* (2008) reported hatching rate ranging from 50.1% to 73% in different hormone treatment. The hatching rate recorded in this study (Table 2) was higher for both ovulin and ovotide. Olaniyi and Akinbola (2013) reported survival rate of fry after four weeks to be 50.14% in ovaprim and 82.08% in ACPE, while Adebayo *et al.*, (2008) observed survival rate

of greater than 60% after 30 days rearing. Luiz *et al.* (2012), reported that fish larvae that cannot properly identify food due to low light exposure would have decreased survival and growth rate. But Adewolu *et al.* (2008), reported that, photoperiod effects vary on species of fish and stage of growth of the larvae. Feeding prior to utilization of barbells to search for food influences high survival and growth performances (Olaniyi and Onitogun, 2013).

Orji, *et al.* (1997) stated that failure in fertilization and hatchery during induced spawning may also be due to environmental and physic-chemical factors such as salinity. The water physic-chemical parameter recorded in this study as seen in tables 3 and 4 are within the acceptable range.

Table 1. The Average Weight Of Female, The Average Number Of Eggs Collected, The Latency Period And The Age Of Brood Fish

Treatment	AWB (kg)	ANE	QH/kg	AB (year)	LP (hours)
Ovalin	0.73 ± 0.23	99200	0.5	1 – 1.5	9
Ovatide	0.75 ± 0.19	101266.7	0.5	1 – 1.5	9

Table 2. The Percentage Fertilization, Hatchability And Survival Rate Of The Larvae After Four Weeks

Treatment	Fertilization (%)	Hatchability (%)	Survival rate (%)
Ovalin	80 ± 20.34	75.31 ± 28.40	40.66 ± 24.77
Ovatide	79.60 ± 30.67	74.56 ± 22.08	45.07 ± 28.29

Conclusion

The result of this study has shown that there is no significant difference among the two hormones investigated in all the parameters investigated meaning that either of them could be used during induced spawning. This could further reduce the cost of fingerling production since some of these hormones cost more than others. More work need to be done to further investigate the reason for low result in African catfish fingerling production.

References

- Adebayo, O. T. and Popoola, O. M. (2008) Comparative Evaluation and Efficacy and Cost of Synthetic and non Synthetic Hormone for artificial breeding of African Catfish (*Clarias gariepinus*). *Journal of Fish Aquatic Science*. 3: 66 – 71
- Adewolu, M. A., Adeniji, C. A. and Adejobi, A. B. (2008) Feed utilization, growth and survival of *Clarias gariepinus* (Burchell 1822) fingerling cultured under different photoperiods. *Aquaculture*. 283: 64 – 67.
- FAO (1996) Artificial Reproduction and pond rearing of African catfish (*Clarias gariepinus*). Food and Agriculture Organization of the United Nation. Fisheries and Aquaculture Department, Rome. 4: 38 – 48.
- Agbebi, O. T., Faseluka, O. and Idowu, A. A. (2013) Effects of Various Latency Periods on the fertilization, Hatchability and Survival of *Clarias gariepinus*. *Journal of Fisheries and Aquatic Science*. 8 (1): 178 - 183
- Khan, A. M., Abdullah, H., Ashraf, S. M. and Ahmad, Z. (2006). Induced spawning of Labeo rohita using synthetic hormone. *Punjab University Journal of Zoology* 21: 67 – 72
- Kulwal, B. Y., Wokton, W. J., Vou, A. K. Sambo, A. B. and Okunsebor, S. A. (2017). Manipulation of synthetic hormone in induced breeding of Catfish, *Clarias gariepinus* (Burchell 1822). *International journal of Multidisciplinary Research and Development* 4: 01 - 05
- Luiz, G. G., Haluk, M. and Joao, B. K. F. (2012) Effect of photoperiod on reproduction of Slamese fighting fish (*Betta splendens*). *R. Bras Zootec*. 41: 821 – 826.
- Mosha, S. S. (2018) Rent comparative Studies on the performance and survival rate of African catfish (*Clarias gariepinus*) larval produced under Natural and Synthetic Hormones: A Review. *J. Aqua. Res. Develop*. 9: 3
- Ngueku, B. B. (2015). The efficacy of synthetic and non synthetic hormone in the induced spawning of the African Catfish (*Clarias gariepinus* Burchell 1822). *Int. J. Fish Aquat. Studies* 3: 34 – 37.
- Nwokoye, C. O., Nwuba, I. A. and Eyo, J. E. (2007) Induced propagation of African clarid catfish, *Heterobranchus bidorsalis* using synthetic and homoplastic hormones. *Afr. J. Biotechnology*. 6: 2687 – 2693.
- Olaniyi, C. O., and akinbola, D. O. (2013). Comparative Studies on the hatchability, performance and survival rate of African catfish (*Clarias gariepinus*) larval produced using Ovaprim and catfish pituitary extract hormones. *Journal of Biology, Aquaculture and healthcare* 3: 57 – 62.
- Olaniyi, O. A., Ayinia, O. A. and Adeyemo, A. A. (2005). The effects of various doses of Ovaprim on reproductive performance of the African catfish, *Clarias gariepinus* (Burchell) and *Heterobranchus longifilis* (Valenciennes). *African Journal of Applied Zoology and Environmental Biology* 7: 101 – 105.

- Olaniyi, W., and Omitogun, O. (2013) Stages in the early and larval development of the African catfish, *Clarias gariepinus* (Teleostei Clariidae). *Zygote*. 22: 314 – 330.
- Oyelese, O. A. (2006). Water Temperature, a determinant of fertilization and hatchability rates I artificially induced breeding of *Clarias gariepinus* (Teleostes: clariidae). *Res. J. of BioL. Sci.* 1: 83 – 87.
- Orji, R. C. A., Nnadi, C. N. and Onyika, G. (1997) Effect of different Salinity Levels on the fertilization and hatching of *heterobranchus bidorsalis*. *NAGA, the ICLARM, Quarterly*. 21 – 22.
- Sahoo, S. K., Giri, S. S. and Sahu, A. K. (2005). Induced spawning of Asian catfish *Clarias batrachus* (Linn). Effect of various latency periods and SGNRHa and domperidone doses on spawning performance and egg quality. *Aquacult. Res.* 36: 1273.
- Zhuo, Q., Zhang, Y., huang, W., Liu, X. and Li, Y. (2011). Gonadotropin releasing hormone analogue multiple injection potentially accelerated testicular maturation of male yellow catfish *Pelteobagrus fluridruco* Richardson) in captivity. *Aquacult. Res.* 42: 1 – 14.

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Prospects and Challenges of Cryopreservation in Aquaculture**Onwujiariri, C. A¹, Akinrotimi, O. A¹, Ani, N. A.¹ and Nwachukwu, I. C.²**^{1,3}African Regional Aquaculture Centre of Nigerian Institute for Oceanography and Marine Research, P.M.B. 5122, Port Harcourt, Rivers State, Nigeria²National Institute for Hospitality and Tourism, Utako, Abuja, Nigeria**Abstract**

Fish breeding is the bedrock of aquaculture operations. Problems like inbreeding, genetic drift, introgressive hybridization have been affecting the production of quality seeds negatively. Cryopreservation serves as a way out of these problems and a possible answer to produce quality seeds and genetically improved varieties. Cryopreservation in aquatic species in general has been constrained to research activities for many decades. Although, the need for its application and commercialization processes in different parts of the world has become clearer in recent years. This paper therefore reviewed the possibility, prospects and challenges of cryopreservation application in Nigeria. This will serve as a viable tool for improving fish breeding and seed propagation for the sustainability of aquaculture production in Nigeria.

Keywords: Fish breeding, Gametes Preservation, Cryopreservation

Introduction

The steadily growing importance of fish farming has compelled improvements in the technologies necessary for securing the initial and basic requirements for productive aquaculture; namely the production of fish seed for stocking. Fish culture today is hardly possible without the artificial propagation of fish seeds of preferred cultivable fish species. The need for the production of quality fish seed for stocking the fish ponds and natural water bodies has indeed increased steadily (Maria *et al.*, 2016). Artificial propagation methods constitute the major practicable means of providing enough quality seed for rearing in confined fish enclosure waters such as fish ponds, reservoirs and lakes (Cabrita *et al.*, 2008). The production of marketable fish fingerlings or juveniles into rearing environment that assures optimum and rapid growth to allow harvest in the shortest possible time. The fish farmer has to obtain adequate number of young fish to meet his production goals. The possibilities of obtaining fish seed in adequate numbers from natural source is rather limited. Even the spawners which, reproduces successfully in confined enclosures are propagated artificially. Apart from being able to obtain quality seed, the artificial propagation technique can also be used to develop strains superior to their ancestors by the methods of selective breeding and hybridization. Depending on the perfection of the system, at least 65% of the eggs produced can be raised to viable fingerlings as against less than 1% survival rate in natural spawning.

It is through this method that out of season supplies of fingerlings are achieved. (Atanda, 2007; Williams *et al.*, 2008). However, the quantity and quality of fish seeds produced remained a major concern. Fish seed demand far outstrips the supply (Olanrewaju *et al.*, 2014), and this has been linked to scarcity of viable broodstock especially depletion of male broodstocks due to sacrificial method mostly used. Also, the seed quality has been deteriorating over the years due to inbreeding, hybridization and improper broodstock management. Therefore, it is becoming increasingly difficult to come across pure breed of African catfish. Cryopreservation is now being encouraged as a mean of conserving the male broodstock, curbing the collapse of pure breed of indigenous species and enhancing sustainable seed production. Cryopreservation is a process in which a living cell is frozen, stored and thawed for fertilizing egg without losing its viability (Cryobiosystems, 2006). Despite this, Omitogun *et al.* (2006) had earlier noted that one way of expanding aquaculture in Nigeria is by devising a means of preserving genetic resources of our broodstock for all year round supply of fish seed through cryopreservation. Successful fry production using cryopreserved sperm has been reported for many economically important fish species (Cabrita *et al.*, 2008). It has been estimated that sperm from more than 200 fish species has been successfully cryopreserved (Amupitan *et al.*, 2010). Unfortunately, the technology of cryopreservation has not been reasonably adopted in Nigeria aquaculture industry probably due to lack of awareness/technological challenges. This paper therefore, draws the attention of stakeholder in Nigeria aquaculture industry to the need for the adoption of cryopreservation as a tool for boosting catfish production.

Description of Cryopreservation

The term cryopreservation is used to describe the freezing and long-term storage of living cells, tissues and organs. (Amupitanet *et al.*, 2010) Tierschet *et al.* (1994), define cryopreservation as a process where biological materials such as cells and tissues are preserved by cooling to very low temperatures, typically, -196°C (in case of liquid nitrogen), yet remain viable after exposure to temperatures above 0°C. Cryopreservation is a long-term storage technique with very low temperatures to preserve the structurally intact living cells and tissues for extended period of time at a relatively low cost. Cryopreservation is to preserve and store the viable biological samples in a frozen state over extended periods of time. A very important part of research in cryopreservation is to reveal the underlying physical and biological responses of the cell and cause of cryoinjury, especially those associated with the phase change of water in extracellular and intracellular environments (Sequet *et al.*, 2000). From the original slow-cooling study, another cryopreservation approach has moved to easier and more efficient technique-vitrification, Cryoprotective agents has to gain access to all the parts of the system. Cryopreservation considers the effects of freezing and thawing.

Therefore, the diffusion and osmosis processes have important effects during the introduction of cryoprotective agents, the addition or removal of cryoprotectants, the cooling process, and during thawing. These phenomena are amenable to the experimental design and analysis. Thus, reliable methods can be developed for preserving a very wide range of cells and some tissues. These methods have found widespread applications in biology, biomedical technology and conservation (Omitogun *et al.*, 2006). Cryopreservation technology applied to preservation of fish gametes in aquaculture plays an important role in seed production, genetic management of broodstock and conservation of aquatic resources. Fish germplasm also plays a significant role in human genomic studies because its relatively small size of the genome makes it easier for sequencing and ideal models for studying the human disease. This would help in identifying the roles for human genes from fish mutations and also in fish models for genes identified by human disease (Omitogun *et al.*, 2010). Aquatic species preservation would assist the development, protection and distribution of research lines and would offer benefits for restoration of endangered species.

Benefits of Cryopreservation

Successful cryopreservation is well established for sperm cells from many fish species, but a technique for true cryopreservation of ova has not been achieved (Billard and Zhang, (2001)). Cryopreservation of sperm is a useful technique that can assist reproductive efforts by allowing spawning to take place whenever females are ready. It reduces the need for males, and can increase flexibility and genetic diversity in spawning protocols. Cryopreservation has proved its worth in the animal husbandry and milk production, and can also be a useful tool for quality seed production in hatchery. The Need for Cryopreservation of Sperm Fish Farming has remained an important industry in several countries including Nigeria, where mass seed production through modern breeding techniques is imperative to meet the demand of ever growing investors. It is noteworthy that obtaining fish seed for pond stocking at the right time depend on correct and careful planning of broodstock management. Therefore, optimal broodstock husbandry management remains a key issue for reproduction control. One of the critical limiting factors to catfish seed production has been the seasonality in availability of viable broodstocks which make fingerlings scarce and thus expensive during dry season. Studies of hatchery operation have also suggested that loss of male broodstock is common during breeding operation. (Omitogun *et al.*, 2010), emphasized that a major catfish aquaculture constrain is the shortage of reliable males for breeding. Cryopreservation, an economic tool for genetic resources allows for increase number of offspring from genetically superior males, more efficient transport of semen for later use, and all year round supply of male gametes (Rilleyet *et al.*, 2004). The possibility of improve productivity in aquaculture by cryopreservation is very promising as it helps farmers to worry less about keeping male broodstocks. Cryopreservation of fish sperm provides a tool by which reproduction is optimized during larva production, thereby improving breeding and fish conservation programs. This technology is new to aquaculture industry in Nigeria but has long been adopted in livestock production. The use of cryopreserved gamete in fish breeding is intrinsically desirable in African catfish aquaculture production.

According to Tiersch (Tierschet *et al.*, 2007), the benefits of cryopreservation in aquaculture include the following:

1. Cryopreservation can be used to improve existing hatchery operations by providing sperm on demand and simplifying the timing of induced spawning.
2. Frozen sperm can enhance efficient use of facilities and create new opportunities in the hatchery by eliminating the need to maintain live males, potentially freeing resources for use with females and larvae.
3. Valuable genetic lineage such as endangered species, research models, or improved farm strains can be protected by storage of frozen sperm.

4. Cryopreservation opens the door for rapid genetic improvement because it can be used in breeding programs to create improved lines and shape the genetic resources available for aquaculture.
5. Cryopreserved sperm of aquatic species will at some point become an entirely new industry itself. Large, highly valuable global markets for cryopreserved sperm of aquatic species are on the horizon.
6. It ensures availability of male gamete throughout the year: The availability of gametes throughout the year is important to ensure a constant supply of fish. In captivity (25°C; 12h light per day), *C. gariepinus* gametogenesis is continuous once sexual maturity is reached.
7. However, whereas females can be stripped of eggs after treatment with pituitary extracts, spermatogenesis and male reproductive behavior do not take place spontaneously, even after hormonal therapy. To obtain spermatozoa it is necessary to kill male brood fish or surgically remove the testes. Storing batches of spermatozoa by cryopreservation would significantly improve the reproductive potential of male catfish. The procurement of reliable broodstock (of good genetic quality), fingerlings and juvenile fish for stocking ponds and fish farms has been a major setback in the development of catfish culture in Nigeria. This is because these cultivable species are not easily obtained from the wild.
8. The development of cryopreservation procedures for sperm of *Clarias* species will aid in the recovery of threatened and endangered species as well as in the genetic selection and maintenance of lines of selected stocks.
9. Cryopreserved sperm can also benefit commercial aquaculture industry by allowing females to be spawned when males are not available, decreasing the need to hold captive male as broodstock.
10. It protects fish stock from being totally eliminated due to sudden diseases outbreak, natural disaster, or accidents such as oil spills.
11. Other advantages of cryopreservation include stable supply of sperm for optimal utilization in hatchery production and laboratory experiments,
12. Easy stock transportation among hatcheries,
13. Improvement in selective breeding whereby stock can be maintained more economically and effectively, experimental material for advanced studies, such as gene transfer.

Success of Cryopreservation in African Catfish in Nigeria

Cryopreservation of fish spermatozoa has been the subject of many investigations. Successful cryopreservation depends not only on the right choice of cryoprotectant and extender, but also on the freezing protocol used. Cryoprotectant and freezing rate together determine the damage to spermatozoa due to intracellular ice crystallization. The first two years of the NACGRAB- OAU Department of Animal Sciences cryopreservation project (2005-2007) were dedicated to optimization of cryopreservation protocols of the catfish sperm under short-term condition in deep freezer at -10 to -30°C (Oyeleye and Omitogun, 2007) and testing the viability of cryopreserved sperm by studying the ability of these cryopreserved sperm in fertilizing freshly spawned eggs (Omitogun *et al.*, 2006).

The second phase of the project (2008-2010) was dedicated to cryopreservation of the catfish sperm under long term conditions in liquid Nitrogen (-290°C) and testing the motility and ability to fertilize eggs. Evaluation of optimization and economic feasibility of cryopreserved sperm was also carried out (Omitogun *et al.*, 2010). To this end, cryopreserved sperm in liquid nitrogen in Dewar container was further diluted and cryopreserved from 3-8 months, then was taken to an identified and willing commercial catfish farm with the objective of testing the ability of cryopreserved sperm of African giant catfish to fertilize a whole clutch of eggs from a mature female catfish, normally used by commercial farmers and consequently confirm the viability of using cryopreserved sperm in normal commercial hatchery operations. Their hypothesis was that if cryopreserved sperm is practically tested on commercial scale and is proven economically feasible, being a true reflection of what was obtained in the laboratory (Oyeleye and Omitogun, 2007) then this will help to conserve male brood stock (Omitogun *et al.*, 2010) which are normally slaughtered for fry production of catfish, and likewise ensure all-year round artificial propagation, helping the fish farmers in overcoming the problem of scarcity of male catfish breeders which are often encountered in the dry season.

Process of Cryopreservation

Practically, both short-term (in deep freezer at -35°C) and long-term cryopreservation (in liquid nitrogen, LN2 at -296°C) was developed for catfish sperm (Omitogun *et al.*, 2010). A successful and sustainable technology will require integrated practices for sample collection, refrigerated storage, freezing, thawing, rule for use and disposal,

transfer agreements and database development According to Chew and Zulkafli, the cryopreservation of the semen of freshwater fishes falls under the following general procedures.

- Sperm is collected by hand stripping, or by testis collection and homogenization. Immediately after collection, sperm is stored at 4°C in immobilizing medium. Most sperm can be stored for several days in this medium.
- For cryopreservation, one to 3 volumes of freezing extender such as Ringer's solution, sugarcane water, coconut water, soybean milk, skim milk, taps, caps, Milk in ringer, Honey in ringer, etc. is added to sperm and the mix is loaded into 500 µL straws.
- Freezing is performed in liquid nitrogen vapors, using either a programmable freezer or a Styrofoam frame floating 3cm above liquid nitrogen. Straws are then stored in liquid nitrogen tanks (-196°C). 10 sec.
- Thawed sperm should be immediately used for fertilization, without any washing or recovery step.

Conclusion

Cryopreservation has several benefits such as stock protection, a stable supply of sperm for optimal utilization in hatchery production and laboratory experiments, easy stock transportation, improvement in selective breeding and gene transfer. In fact, fish produce a high viscosity of sperm and in some cases only small volume is produced. Extenders and cryoprotectants are important and play a vital role in cryopreservation. Extenders are needed for sperm dilution to produce large volume of diluted sperm while cryoprotectants are also needed to protect the sperm cell from cold and hot shock treatments and prevent cell dehydration during pre-freezing, freezing and post thawing, and it greatly extends the tolerance of spermatozoa to freezing particularly when it is done at slower rate. The optimal cooling rate depends on the nature and concentration of the cryoprotectant that is used. In addition, the suitability of extenders and cryoprotectants differs from one fish to another.

References

- Amupitan, P.S, Ilori, O.I, Aladele, S.E, Odojin, W. T. and Omitogun, O.G. (2010). Scaling up the viability of cryopreserved giant catfish semen in liquid nitrogen for commercial application. In: 34th Annual Conference of the Genetic Society of Nigeria. NIHORT, Ibadan. Pp 335-343. ISSN 0189-9686
- Cryobiosystems. (2006). Fundamentals of cryobiology- <http://www.Cryobiosystem.imv.com/CBS/Cryobiology/cons.cbs-asp>.
- Maria A. N., Viveiros, A. T. M., Orfao L. H., Oliveira, A. V. and Morales, G. F. (2006). Effects of cooling and freezing on sperm motility of the endangered fish Piracanjuba Bryconorbignyanus (Characiformes, Characidae) Animal Reproduction .Vol. 3 No. 1 pp. 55-60.
- Omitogun, O.G, Olaniyan, O. F., Oyeleye, O.O., Ojiokpoti, C. Aladele, S.E. and Odojin, W. T.(2010). Potentials of short term and long term cryopreserved sperm of African giant catfish (*Clarias gariepinus* Burchell 1822) for aquaculture. African Journal of Biotechnology Vol. 9 No. 41. pp. 6973-6982, ISSN 1684-5315. Academic Journals.
- Oyeleye, O. O and Omitogun, O. G.(2007). Evaluation of motility of the short-term cryopreserved sperm of African giant catfish (*Clarias gariepinus*). Ife Journal of Agriculture Vol. 22 .No.(1) pp.11-16. Ile-Ife, Nigeria. ISSN 0331-6351.
- Riley, K. L. P. (2002). Refrigerated storage and cryopreservation of sperm for the production of Red snapper and Snapper hybrids. M. Sc Thesis, Agriculture and Mechanical College, Louisiana University. USA. SIGMA (1994). Cell counting and cell viability. Saint Louis, MO 63178 USA. Pp. 1634-1635.
- Suquet, M., Dreanno C., Fauvel, C., Cosson, J. and Billard, R. (2000) Cryopreservation of sperm in marine fish. Aquaculture Research Vol. 31 pp. 231-243.
- Tiersch, T. R., Goudie, C.A. and Carmichael, G.J. (1994). Cryopreservation of channel catfish sperm. Storage in cryoprotectants, fertilization trial and growth of channel catfish produced with cryopreserved sperm. Transactions of the American Fisheries Society Vol. 123 pp. 580-586.
- Atanda AN (2007) Assessment of freshwater fish seed resources for sustainable aquaculture. FAO Fisheries Technical Paper 501, Rome, Italy.
- William SB, Olaosebikan BD, Adeleke AO, Fagbenro OA (2008) Proceeding of a workshop on the development of a genetic improvement programme for African catfish, *C. gariepinus*.
- Olanrewaju AN, Kareem OK, Olaosebikan BD (2014) Nigeria manpower needs and opportunities in freshwater fish seed production. Nigerian Journal of Rural Extension and development 8: 9-11.
- Omitogun OG, Oyeleye OO, Betiku CO, Ojiokpoti C, Aladele SE, et al, (2006) Potentials of short-term cryopreserved sperm of the giant African catfish, *Clarias gariepinus*.

- Cabrita E, Robles V, Herraiz MP (2008) *Methods in Reproductive Aquaculture: Marine and Freshwater Species*. Biology Series - CRC Press (Taylor and Francis group), New York, USA.
- Akçay E, Bozkurt YSSE, Tekun N (2004) Cryopreservation of Mirror Carp Semen. *Turkish Journal of Veterinary and Veterinary Animal Science* 28: 837843.
- Tiersch T. R (2008) Strategies for commercialization of cryopreserved fish semen. *R Bras Z*

**OMMITTED MANUSCRIPTS
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Growth Performance and Survival of African Catfish *Clarias gariepinus* (Burchell, 1822) Reared in Covered and Uncovered Concrete Tanks

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Abstract

Fingerlings of *Clarias gariepinus* (mean weight 2.26 ± 0.84 g) were reared in shaded and unshaded tanks for a period of six months to investigate the influence of sunlight intensity on growth and survival under controlled environmental settings. The fish were fed with Vital feed. The results obtained from the study indicated that the final mean weights of 489.15 ± 103 g (shaded tanks) and 404.75 ± 74.19 g (unshaded tanks) and final mean total lengths of 34.45 ± 6.77 cm (shaded tanks) and 25.66 ± 8.83 cm (unshaded tanks) were observed in the reared in different conditions. The mean survival rates were 52.50 ± 7.48 % (shaded tanks) and 75.02 ± 8.69 % (unshaded tanks). Also, water quality parameters were monitored in the tanks during the study. Fish in shaded tanks had significantly higher ($p < 0.05$) mean weight gain than unshaded tanks while fish in unshaded tanks had significantly higher ($p < 0.05$) survival rates, which is attributed to higher values of dissolved oxygen in unshaded tanks due to the photosynthetic activities of phytoplankton.

Key words: Aquaculture, Catfish, Growth, Culture Systems, Survival

Introduction

The Nigerian aquaculture industry is endowed with a rich diversity of cultivable fish species, vast freshwater and brackish water fisheries resources, good weather and good climatic conditions (Tobor, 1990). The current aquaculture research efforts in Nigeria, focus on optimization of culture practices for existing cultivable species, without taking cognizance of the impacts of environmental factors such as temperature and sunlight on the cultured species. Buttner *et al.* (1993) reported that all biological and chemical processes in an aquaculture operation are influenced by temperature. Each fish species has a preferred or optimum temperature range for optimum growth. To this effect, under culture conditions in stratified ponds, fish naturally adjust their body temperature by moving to cooler or warmer water layers. At temperatures above or below the optimum range, fish growth is reduced. Knowledge of water temperature regimes is essential for site evaluation, species selection and pond management. However available information in this subject area is scanty. Temperature increases oxygen consumption and ammonia ($\text{NH}_3\text{-N}$) excretion in fish through increased metabolic activities (Chin and Kou, 1996). Some catfish farms in Nigeria are operated in covered concrete tanks that is, under shed because this is believed to offer stable temperature conditions while many others are operated in uncovered tanks. What is the advantage of rearing fish in covered tanks compared to uncovered tanks in tropical climate settings such as Nigeria? The objective of this study therefore, is to compare the effects of surface water temperature variations on the growth performance of *Clarias gariepinus* fingerlings reared in indoor and outdoor concrete tanks.

Materials and Methods

Study Area

The study was carried out in four concrete tanks in African Regional Aquaculture Centre (ARAC), located at Omuihuechi, Aluu, Rivers State, Nigeria. ARAC lies between longitudes $4^\circ 54'$ and $4^\circ 56'$ East and latitudes $6^\circ 53'$ and $7^\circ 00'$ North.

Fish and Experimental Design

The experimental fish *Clarias gariepinus* of the family – *Clariidae* were obtained from a private fish farm located in Port Harcourt, Nigeria. The study was conducted in four concrete tanks of dimensions 2.0 m x 1.2 m x 1.0 m. Two of the tanks were kept outdoors while the other two were kept under shed (Plate 1). The tanks were cleaned, sterilized, filled with water up to 80 cm mark; and stocked with fingerlings of *C. gariepinus* of average total length 6.32cm and average weight 2.26g at stocking rate of 100 fish /tank. The tanks were not covered (screened) with net.

The experiment lasted for six months after stocking. The fingerlings were fed with Vital feed of crude protein (CP) level of 40% at 5% of fish body weight twice daily at 08:00 and 17:00 hours.

Fish growth monitoring

Fish growth was monitored fortnightly by taking 10 fish samples from each tank and measuring the total length (L) and weight (W) of each fish. Total length of each fish was taken from the tip of the snout (mouth closed) to the extended tip of the caudal fin using a measuring board while fish body weight was measured to the nearest gram using a sensitive balance. This was carried out for three fish growth segments namely post fingerlings, juvenile fish and adult fish. The condition factor (Cf) was calculated using the formula: $Cf = 100W/L^3$ (Pauly, 1993).

Water quality monitoring

The following water quality parameters were monitored every two weeks by taking water samples from the experimental tanks and subjecting them immediately to analysis in the laboratory using standard methods (APHA, 1995; Lamotte, 2006): hydrogen ion concentration (pH), dissolved oxygen (DO), temperature, total alkalinity, total hardness, Chloride, and transparency. Hydrogen ion concentration (pH), dissolved oxygen, total alkalinity, total hardness, and Chloride were measured using lamotte fresh water aquaculture test kit (model AQ-2/code 333-03). Surface water temperature was measured with mercury in-glass thermometer while transparency was measured in-situ using a weighted white Secchi disk of diameter 12 cm to which was attached a calibrated line on the upper side.

Results

The results obtained in this study are presented in Tables 1 and 2. Table 1 shows the results of the water quality parameters in the experimental tanks throughout the study period. Significant differences ($p < 0.05$) between covered and uncovered tanks were recorded in the values of temperature, pH, total alkalinity, total hardness, dissolved oxygen and transparency. While only the chloride values were within the same range. In Table 2, data are shown on mean weight gain in relation to mortality and recovery. Higher values of final mean weight, mean weight gain, length increase and condition factor were higher in shaded than the unshaded tanks. While performance index and survival of fish was higher in uncovered than the covered tanks (Table 2).

Table 1: Values of Selected Water Quality Parameters in Covered and Uncovered Tanks (Mean $\pm$ SD)

Parameters	Covered Tanks	Uncovered Tanks
Temperature($^{\circ}$ C)	26.43 $\pm$ 2.89 ^a	27.80 $\pm$ 3.12 ^b
pH	6.98 $\pm$ 0.67 ^a	7.15 $\pm$ 0.82 ^b
Total alkalinity (mg/L)	70.51 $\pm$ 20.32 ^b	62.01 $\pm$ 19.07 ^a
Total hardness (mg/L)	91.65 $\pm$ 10.32 ^b	67.34 $\pm$ 6.02 ^a
Dissolved oxygen(mg/L)	3.33 $\pm$ 0.62 ^a	5.37 $\pm$ 0.88 ^b
Chloride(mg/L)	13.34 $\pm$ 3.45 ^a	13.88 $\pm$ 3.07 ^a
Transparency (cm)	42.25 $\pm$ 4.32 ^b	35.60 $\pm$ 4.11 ^a

Means within the same roll with different superscripts are significantly different ($P < 0.05$)

Table 2: Growth Performance and Survival of *C.gariepinus* Reared in Covered and Uncovered Tanks (Mean $\pm$ SD)

Growth Performance	Covered Tanks	Uncovered Tanks
Initial mean wt (g)	2.29 $\pm$ 0.04 ^a	2.30 $\pm$ 0.07 ^a
Final mean wt (g)	489.15 $\pm$ 35.66 ^b	389.42 $\pm$ 30.02 ^a
Mean wt gain (g)	486.87 $\pm$ 35.66 ^b	387.12 $\pm$ 29.74 ^a
Initial length (cm)	6.35 $\pm$ 1.12 ^a	6.30 $\pm$ 1.07 ^a
Final length (cm)	34.47 $\pm$ 3.89 ^b	28.94 $\pm$ 3.12 ^a
Length Increase (cm)	28.18 $\pm$ 3.02 ^b	22.68 $\pm$ 3.22 ^a
Survival rate (%)	52.05 $\pm$ 7.48 ^a	75.01 $\pm$ 8.69 ^b
Performance Index	261.24 $\pm$ 26.41 ^a	290.36 $\pm$ 29.62 ^b
Feed consumed (kg)	30.79 $\pm$ 3.03 ^a	34.84 $\pm$ 3.99 ^a
Condition factor	0.78 $\pm$ 0.04 ^b	0.68 $\pm$ 0.02 ^a

Means within the same roll with different superscripts are significantly different ($P < 0.05$)



Plate 1. The covered and uncovered experimental tanks

Discussion

From the result so far obtained the weight gain for the covered tanks is higher than the uncovered tanks. On the other hand the mean % recovery was lower (52.5%) in the covered tanks than in the uncovered tanks (75%). Assessment of the condition factor values, *k* indicated that the fish stocked in uncovered tanks were in better condition than those in covered tanks. The significant increase in the length and weight of *Clarias gariepinus* maintained under shaded tanks as compared to the unshaded tanks was probably due to better feed conversion efficiency, the absence or reduction of stress and aggressiveness, as well as the suppression of locomotory activities in the dark. All these enabled more energy, which would have been expended on these metabolic activities to be converted into body growth. This is similar to the result obtained by Almazan-Rueda *et al.* (2005), Appelbaum and Kamler (2000), and Adewolu (2008) reported growth, increase in *Clarias gariepinus* under shaded rearing enclosures and suggested reasons like high feeding activity in the dark for the high growth rate.

Fish reared under continuous shade or exposures to light have become adapted to these photoperiods, thus, they live with them. The constant change between day and night affected the physiology, feeding efficiency, and metabolism of the fish. This change made the fish more aggressive with the attendant increase in swimming activity thus stressing the fish. All these metabolic activities consumed energy, which would have been converted to body weight had it been that the fish were not engaging in higher energy demanding activities. Growth in fishes however is a measure of the relationship between the length/weight and condition factor of the fish exposed to different photoperiods (Almazan-Rueda *et al.*, 2005).

Data on water quality parameters showed a marked difference only for dissolved oxygen, surface water temperature and Secchi transparency readings. The values for dissolved oxygen for the uncovered tanks which ranged from 4.1 to 6.3mg/L were considered within the recommended range for profitable fish production compared with covered tanks which ranged from 1.6 to 3.3mg/L. The higher values of DO recorded in uncovered tanks were attributed to the photosynthetic activities of phytoplankton. This is deduced from the colour of tank water (Plate 1) which was predominantly greener in covered tanks than uncovered tanks. The Secchi transparency readings were slightly higher in the uncovered tanks than the covered tanks. This was expected since the readings were obtained during the rainy season. The values of temperature readings showed that the water temperature values for the covered tanks were lower than that of uncovered tanks by about 1°C. This was also expected.

Conclusion

It has been observed, in this trial, that the provision of shade gave better growth performances in *C. gariepinus*. Thus, it is established that provision of shades can improve productivity of *C. gariepinus*, without affecting its survival.

References

- Adewolu M.A., Adeniji C.A., and Ademola, B.A. (2008). Feed utilization, growth and survival of *Clarias gariepinus* (Burchell, 1822) cultured under different photoperiods *Aquaculture* 283:64-67.
- Almazan-Rueda P., Van Helmond A.T.M., Verreth J.A.J. and Schrama J.W. (2005). Photoperiod affects growth, behavior and stress variables in *Clarias gariepinus* *Journal Fish Biology* 67: 1029-1039.

- Appelbaum, S. and Kamler, E. (2000). Survival, growth, metabolism and behaviour of *Clarias gariepinus* (Burchell) early stages under different light conditions *Aquaculture*. England, 22:269- 287
- APHA (Standard methods for the examination of water and wastewater)(1995). 19th Edition. American Public Health Association. Washington DC.
- Ajayi T.O.(1991).Highlight of achievements in the last 30 years by Nigerian Institute for Oceanography and Marine Research and its parent research division of the Federal Department of Fisheries, Lagos.Tobor J.G.(Ed.). NIOMR, Lagos, Nigeria.23pp.
- Buttner,J.K.,Soderereg,R.W.andTerlizzi,D.E.(1993). *An introduction to water chemistry in freshwater aquaculture*.North Eastern Regional Aquaculture Centre Publ. No.170. 40pp.
- Chen, J.C. and Kou ,T.T.(1996). Effects of temperature on oxygen consumption and nitrogen excretion of juveniles of *Machrobrachiumrosenbergii*.Dept. of aquaculture, National Taiwan Ocean Univ. Keelung Taiwan. p1.
- Tobor,J.G.(1991). Foreword to the proceedings of the fish seed propagation course. In; Ayinla, O.A.(Ed.). *Proceedings of the fish seed propagation course* .Nigerian Institute for Oceanography and Marine Research, Lagos.pp104.
- Lamotte (2006). Freshwater aquaculture water quality test kit instrument manual. Model AQ-2/code 3633-03.Lamottecompany.

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Changes in Electrolytes in *Sarotherodon melanotheron* Exposed to Different Chemicals in the Laboratory

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Abstract

Variations in some electrolytes such as Sodium (Na^+), Potassium (K^+), Chloride (Cl^-) and Calcium (Ca^{2+}) in the plasma of *Sarotherodon melanotheron* **exposed** to three different chemicals: paraquat dichloride (PARAQ), 2,2-dichlorovinyl phosphate (DDVP) and dimethoate (DMC) at the concentrations of 0.00 control, 0.50, 1.00, 1.50, 2.00 and 2.50 mg/L were carried out to determine the levels of osmotic impairment on fish exposed to these chemicals. A total of 150 adult sizes of *S. melanotheron* were used for the study. Results from the study indicated that the values of Na^+ and K^+ ions significantly increased ($P < 0.05$) in the exposed fish when compared to the control values. However, significant reduction ($P < 0.05$) of Ca^{2+} was equally observed in the treated fish and no significant difference ($P > 0.05$) in the values of Cl^- between the control and exposed fish. Comparatively, these alterations were more pronounced in the fish exposed to paraquat dichloride.

Keywords: Aquatic Environment, Electrolytes, Pesticides, Osmoregulation, Fish

Introduction

Pesticide pollution in the aquatic environment has attracted the attention of researchers and policy makers across the globe (Adeolu *et al.*, 2010). Typically, the use of pesticides has increased within the last few decades due to its extensive use in agricultural and industrial processes; as such they are becoming threats to living organisms (Adonis *et al.*, 2003). Contamination of aquatic environments by pesticides in turn leads to oxygen depletion; poisoning and resultant mass mortality of fishes. Fish has the tendency to accumulate toxicants from their environment using their various parts. Conversely, xenobiotics such as pesticides could lead to physiological dysfunction in various biological system, haematological index, behavioural response, biochemical, electrolytes alterations in fish (Gabriel *et al.*, 2012a).

Evaluations of electrolyte parameters in the blood of an organism are good indicators of assessing the health status of fish in ecotoxicology. The electrolytes are substances which influence the distribution and retention of water around the system of an individual. Gabriel *et al.* (2011) reported that sodium and potassium are the most important osmotically effective electrolytes and hence the most studied. Others of importance are chloride and calcium. Calcium is present in the body in larger amounts than in any other mineral element. Changes in Electrolytes levels indicate the operation of a variety of homeostatic mechanisms in the body of fish and play an important role in osmoregulation (Ates *et al.*, 2008; Aguigwo, 2012). It is difficult to assess the level of toxicity of pesticides on organisms in the aquatic environment because of the complex nature of aquatic ecosystems. Thus toxicological methods have been seen as an adequate evaluation technique for assessing toxicants on the aquatic population (Linde *et al.*, 2004). The present paper contributes to the assessment of toxicity and the effects of some chemicals on the electrolytes levels in *S. melanotheron*, an euryhaline specie commonly found in the brackish water zone in Nigeria.

Materials and Methods

Experimental Location and Fish

The study was carried out in African Regional Aquaculture Center, an outstation of Nigerian Institute for Oceanography and Marine Research, Buguma, Rivers State, Nigeria.

One hundred and fifty *S. melanotheron* (mean length 11.98 ± 1.56 cm; mean weight 122.03 ± 2.06 g) were sourced from ponds during the low tide. The fishes were transported in six open 50l open plastic containers to the laboratory and acclimated for a period of seven days.

Preparation of Test Solutions and Exposure of Fish

Three pesticides namely; paraquat dichloride (PARAQ), 2,2-dichlorovinyl phosphate (DDVP) and dimethoate (DMC) used in this experiment were purchased from a commercial outlet in Port Harcourt, Nigeria. The fish were exposed to each of the chemical at the concentrations of 0.00 control, 0.50, 1.00, 1.50, 2.00 and 2.50 mg/L in triplicates. Ten fish were randomly distributed into each test tank. The experiment lasted for a period of 15 days. The water in the tanks was renewed daily. The fish were fed twice daily at 3% body weight with a commercial feed.

Determination of blood serum electrolytes

At the end of each experimental period, 2ml of fresh blood sample was collected by making a caudal puncture with the help of fine needle and poured in heparinized sample bottles. Serum was separated by centrifugation at 10,000rpm for 5-8 minutes in TG20-WS Tabletop High Speed Laboratory Centrifuge. Serum electrolytes such as Na⁺, K⁺, Ca²⁺ and Cl⁻ were determined by using Hitachi 902automatic analyzer (Japan), following the method described by Gabriel et al. (2010). All the tests were performed in triplicates.

Statistical Analysis

All the data were expressed as mean and standard deviation of mean. The statistical package, SPSS Version 22 was used for the data analysis. The means were separated using one way ANOVA and the two means were considered significant at 5 % (P<0.05).

Results

The resultant effects of paraquat dichloride on the electrolytes in the plasma of *S.melanotheron* are presented in Table 1. It was observed that sodium ion (Na⁺) and K⁺ increased with increasing concentrations of the pesticides. Also Ca²⁺ decreased significantly when compared to the control values. While Cl⁻ were within the same range of 15.0- 18.0 (Table 1). In the plasma of fish exposed to DDVP, these ions Na⁺, K⁺, and HCO₃⁻ fluctuated significantly (P<0.05) when compared to the control values. While Na⁺ and K⁺ increased and peaked at 3.00 mg/L of the chemical. The values of calcium ions reduced significantly with increasing concentrations of the chemical. Whereas Cl⁻ ion were within the same range of 13.00-15.00 across the concentrations (Table 2). In the fish treated with DMC there was significant variation across the concentrations of exposure in all the ions. At the same time Na⁺ and K⁺ increased and peaked at 2.50 mg/L of the chemical (Table 3).

Table 1: Effects of Paraquat Dichloride on the electrolytes ions in the Plasma of *S.melanotheron* (Mean±SD)

Conc.(mg/L)	Na ⁺	Ca ²⁺	K ⁺	Cl ⁻
0.00	40.30 ± 1.01 ^a	38.88 ± 2.09 ^e	2.40 ± 0.99 ^a	13.00 ± 1.02 ^a
0.50	44.50 ± 2.02 ^a	25.02 ± 2.19 ^d	3.80 ± 1.03 ^a	14.00 ± 1.04 ^a
1.00	50.80 ± 1.20 ^b	22.77 ± 1.45 ^c	5.50 ± 0.02 ^b	15.00 ± 1.99 ^a
1.50	60.90 ± 1.02 ^c	18.04 ± 2.09 ^c	7.10 ± 0.01 ^b	16.00 ± 1.19 ^a
2.00	65.50 ± 1.54 ^c	14.50 ± 1.04 ^b	10.03 ± 0.04 ^c	15.00 ± 2.02 ^a
2.50	70.99 ± 2.01 ^d	8.56 ± 1.08 ^a	11.20 ± 0.18 ^c	15.00 ± 1.01 ^a

Means in the same column with different superscripts are significantly different (p<0.05)

Table 2: Effects of 2,2-dichlorovinyl phosphate on the electrolytes in the Plasma of *S.melanotheron* (Mean±SD)

Conc.(mg/L)	Na ⁺	Ca ²⁺	K ⁺	Cl ⁻
0.00	40.37 ± 1.09 ^a	38.59 ± 2.01 ^c	2.42 ± 0.22 ^a	13.00 ± 1.08 ^a
0.50	41.20 ± 2.11 ^a	30.03 ± 2.55 ^c	2.40 ± 1.98 ^a	16.00 ± 1.98 ^a
1.00	45.10 ± 1.11 ^b	29.43 ± 1.21 ^b	4.40 ± 1.11 ^b	15.00 ± 1.99 ^a
1.50	51.90 ± 1.87 ^c	26.20 ± 2.11 ^b	6.60 ± 1.14 ^b	14.00 ± 1.43 ^a
2.00	61.70 ± 1.64 ^c	24.50 ± 1.33 ^a	8.80 ± 1.88 ^c	15.00 ± 2.04 ^a
2.50	66.44 ± 2.87 ^d	22.99 ± 1.45 ^a	10.90 ± 1.32 ^c	16.00 ± 1.01 ^a

Means in the same column with different superscripts are significantly different (p<0.05)

Table 3: Effects of Dimethoate (DMC) on the Electrolytes ions in the Plasma of *S.melanotheron*(Mean±SD)

Conc.(mg/L)	Na ⁺	Ca ²⁺	K ⁺	Cl ⁻
0.00	42.30 ± 1.01 ^a	38.50 ± 2.01 ^c	2.40 ± 0.29 ^a	13.00 ± 1.81 ^a
1.00	44.76 ± 2.11 ^a	33.11 ± 2.44 ^c	2.58 ± 1.19 ^a	14.00 ± 1.98 ^a
1.50	46.21 ± 1.13 ^a	30.99 ± 1.43 ^b	3.08 ± 1.77 ^b	14.00 ± 1.03 ^a
2.00	50.12 ± 1.54 ^b	28.88 ± 2.34 ^a	4.39 ± 1.78 ^b	15.00 ± 1.02 ^a
2.50	54.65 ± 1.19 ^b	27.86 ± 1.13 ^a	6.99 ± 1.88 ^c	14.00 ± 2.09 ^a
3.00	58.88 ± 2.05 ^c	25.17 ± 1.43 ^a	8.58 ± 1.92 ^c	15.00 ± 1.47 ^a

Means in the same column with different superscripts are significantly different (p<0.05)

Discussion

Electrolytes are needed for osmoregulatory purposes in the body system of living organisms, thus electrolyte balance in the body of organism is necessary for the normal function of cells and organs. Gabriel *et al.*(2012), revealed that the basic function of electrolytes in the body include the control of fluid distribution, intracellular and extracellular acido-basic equilibrium so as to achieve proper maintenance of osmotic pressure of body fluids and normal neuro-muscular irritability. Therefore, alterations of the electrolyte balance of an organism would adversely affect the organism concerned. These functions can be compromise with stress due to the toxicant effect on the fish physiology. A slight stabilization of values in this present study is an indication that the pesticides affect the *Clarias gariepinus* electrolytes system in the tissue. Additionally, this stabilization may be as a result of low concentration of the toxicant used in this experiment. This perhaps confirms the low toxicological effect of these chemicals on fish. Slight fluctuation in sodium (Na⁺) values was also reported by Awoyinka *et al.*(2011) when they exposed *Clarias anguilaris* to crude oil. According to Nte and Akinrotimi (2011) slight change in values of these electrolytes can disturb osmotic and ionic regulation in fishes as well as general physiology in the fish.

Potassium is the major cation of intracellular fluid and regulates intracellular osmotic pressure and acidic base balance. Changes in these values compared to control, is an indication that certain physiological functions such as maintenance of intracellular osmotic pressure, acid base balance, and stimulating effect of muscle irritability as well as protein and glycogen synthesis could be distorted due to the exposure to pesticides (Gabriel *et al.*, 2012). The present study compares with that of Akinrotimi and Gabriel (2012) who reported a significant increase in the values of K⁺ after *Clarias gariepinus* was exposed to cypermethrin. They opined that increase in K⁺ ions could be an indication of stress induced response occasioned by the chronic exposure of fish to toxicants which may have activated certain physiological and metabolic mechanisms that could lead to a rapid uptake of the electrolytes from water, food, and possible reduction of ion efflux. Potassium and sodium ions are readily absorbed from gastrointestinal tract, and gills of fish, thus the variance in electrolyte ionic imbalance in exposed fishes is an indication of toxic effect of the contaminant on *Clarias gariepinus*, this may have caused osmotic gradient present in the gills and body surface and ultimately drawn out monovalent and divalent ions in the probe organism. The reason for electrolytes ions fluctuation in the plasma of the exposed fish may be due to increased cell membrane permeability, as pointed out by Akinrotimi and Nte (2011), allowing the intracellular ions to diffuse passively to extracellular fluid.

Conclusion

This study also showed that each of the toxicants caused significant alterations in electrolytes profiles of the exposed *S.melanotheron*, a clear indication that their usage in the fields and water environment may be a threat to aquatic biota. Sustainable and environmental friendly farming systems must be advocated for in different parts of the country. Total changes to a new system of approach in crop protection procedures are paramount and urgent in order to resolve the economic and environmental consequences in application of pesticides.

References

Aderolu, A.Z., Ayoola, S.O., & Otitolaju, A.A. (2010). Effects of acute and sub-lethal concentrations of Actellic on weight changes and haematology parameters of *Clarias gariepinus*. *World Journal of Biological Research*, 3:30-39.

- Adonis, M., Martinez, V., Riquelme, R., Ancic, P., Gonzalez, G., Tapia, R., Castro, M., Lucas, D., Berthou, F. and Gil, L. (2003). Susceptibility and exposure biomarkers in people exposed to PAHs from diesel exhaust. *Toxicology Letters*, 144:(1)3-15.
- Aguiwo, J.N. (2002). The toxic effect of cymbush pesticide on growth and survival of Africa catfish (*Clarias gariepinus*) *Journal of Fisheries and Aquatic Sciences*, 17(2)81-84.
- Akinrotimi, O and Gabriel U.U. (2012) Alterations of selected electrolytes in organs of african catfish *clarias gariepinus* treated with cypermethrin, *Science Education Development Institute*, 1 : 23-31.
- Akinrotimi, O.A., & Nte, M.D. (2011). Changes in electrolytes in selected organs of Black chin tilapia (*Sarotherodon melanotheron*) treated with industrial effluent. *International Journal of Environmental Sciences*, 1(1): 25 – 30.
- Ates, B., Orun, I., Talas, Z. S., Durmaz, G., & Yilmaz, I. (2008). Effects of sodium selenite on some biochemical and hematological parameters of rainbow trout (*Oncorhynchus mykiss* Walbaum, 1792) exposed to Pb²⁺ and Cu²⁺. *Fish physiology and biochemistry*, 34(1), 53-59.
- Awoyinka, O. A., Atulomah, E., & Atulomah, N. O. S. (2011). Comparative effects of crude oil on juveniles *Clarias gariepinus* and *Clarias anguillaris*. *International Journal of Fisheries and Aquaculture*, 3(13): 239-243
- Gabriel, U.U. Akinrotimi, O.A., & Ariweriokuma, S.V. (2012a). Changes in metabolic enzymes activities in selected organs and tissue of *Clarias gariepinus* exposed to cypermethrin. *Journal of Chemical Engineering*, 1(2): 13-19.
- Gabriel, U.U., Akinrotimi, O.A., & Ariweriokuma, S.V. (2012b). Alterations of selected electrolytes in organs of African catfish, *Clarias gariepinus* treated with cypermethrin. *Advances in students Research*, 2(1), 53-60.
- Gabriel, U.U., Uedeme-Naa, B., & Akinrotimi, O.A. (2011). Pollutant induced altered behaviours in fish: A review of selected literature. *Journal of Technology and Education in Nigeria (JOTEN)*, 16(1), 9-23.
- Linde, A. R., Sanchez-Galan, S. and Garcia-Vazquez, E. (2004). Heavy metal contamination of European eel (*Anguilla anguilla*) and brown trout (*Salmo trutta*) caught in wild ecosystems in Spain. *Journal of food protection*, 67(10), 2332-2336.
- Nte, M.E., & Akinrotimi, O.A. (2011). Biochemical changes in black jaw tilapia (*Sarotherodon melanotheron*) treated with sub lethal levels of industrial effluents. *Advances in Agriculture, Science and Engineering Research*, 1(2), 25-33.

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Covid-19: The Role of Aquaculture in Employment Generation in Nigeria

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Abstract

COVID-19 pandemic, a sudden and strange human disease which started in China in December 2019 began to ravage the whole world and because there was and still no cure or effective immunization till date, huge casualties is being recorded. The pandemic brusquely caused global total lockdown and Nigeria was economically destabilized, resulting in the loss of sources of fishers' livelihoods. Over 6.5 million fishers along Nigeria's Atlantic Coast of about 853km stretch lost their jobs in the first two months of the pandemic. The study established that aquaculture fishery is practiced under safe environment in the COVID era (relative to capture fisheries) and is capable of providing fish as well as generate employment for Nigeria's vast populations throughout the sector's value chain (production to consumption). About 0.35 million producer households would adopt improved breeds, aqua-feeds, fish health and aquaculture and fisheries management practices. It is also proposed that 0.19 million people of which 50% would be women will be exited from poverty through improvements in aquaculture livelihood programmes.

Keywords: Nigerian economy, COVID-19 pandemic, Aquaculture, Employment generation, Value chain.

Introduction

Since the beginning of the Corona Virus Disease (COVID-19) in December 2019 till the period of this paper, 29th of October 2020, 45.3 million people have been infected and about 1.1 million people have died of the infection and 30.3 million recovered globally. In Nigeria, out of the 62,156 confirmed cases, 57,916 recovered while 1,135 people have died (NCDC, 2020). As the pandemic continues to devastate the Nigerian economy, employers in large and small businesses are faced with a dreadful conundrum on whether to let their staff go, cut their hours, or declare them redundant. The impact of COVID-19 on fishermen and livelihoods could be devastating when one considers the ravaging effects of the disease on human, financial, social and economic resources of the nation. Apart from COVID-19 pandemic, the Blue Growth Initiative (Blue Economy) which emphasizes economic, environmental and social sustainability has fisheries (aquaculture in particular) as one of the major means of achieving Sustainable Development Goals (SDGs). However, depending on the particular situation of fish stocks and ecosystems, and the magnitude of reductions in fishing, the crisis could result in positive impacts on the health of some fish stocks, as well as on biodiversity more generally.

More data need to be collected to understand the impacts of the COVID-19 pandemic on fishing effort; moreover, the relationship between fishing effort and stock health is sometimes hard to predict. The possible impact of the crisis on commercially important fish stocks thus remains largely unknown. However, the plight of fishermen was generally expressed by Makoko fishers in Lagos mainland, where it was estimated that about 6.5 million fishers along the coastal communities of the 850 km Atlantic coast line had been impoverished by the impact of the COVID-19 pandemic (FishNet Alliance, 2020).

Generally, government is charged with the responsibility of ensuring good standard of living through gainful employment and social responsibility for the citizens. In an event where this is not visible, government encourages its citizenry to engage in different entrepreneurship activities through the establishment of ventures unveiling several programmes including aquaculture as well as ensuring their success.

Effect of COVID-19 on Employment

Employment generation is a natural process of social development. Human beings bring with them into the world an array of needs that present employment opportunities for others to meet. Were it not so, the world could not have sustained a more than tripling of population over the past century. Employment generation can be achieved through diversification of agriculture, cheap credit, provision of basic facilities, promotion of local industries, improvement in education and health, tourism or regional craft industry, or new services like IT which require proper planning and support from the government. Unemployment and underemployment in Nigeria are caused by more basic

structural factors such as lack of capital, use of capital-intensive technologies, lack of access to land for agricultural household, lack of infrastructure, rapid growth of population resulting in large annual increments in labour force year after year and recently, by the effect of the COVID-19 pandemic.

Nigerians are losing their jobs as both individuals and firms face undaunted challenges due to the snowballing effects of the COVID-19 pandemic currently ravaging the economy. According to the National Bureau of Statistics (NBS, 2020) maiden report, the impact of COVID-19 pandemic on employment and income of Nigerians have been widespread. A high rate of households reported income loss since mid-March 2020 as 79% of household reported that their total income decreased. The rates of losses of income were 85% for non-farm families, 58% for wage-based employment and 75% for farming households in livestock and fishing.

Nigeria's Fisheries

Despite Nigeria's oil resources, agriculture remains the base of the country's economy, providing the main source of livelihood for most Nigerians. Like many coastal developing countries, fish is an important source of food for the population, which is currently estimated at 186 million people (World Bank, 2016). Fisheries is a major economic sector, estimated to employ over 8.6 million people directly and a further 19.6 million indirectly, 70 percent of whom are women. Currently, Nigeria produces just over 1 million metric tons of fish annually, leaving a deficit of over 2 million metric tons, which is usually made up from imports. Recognizing the importance of fish within the agriculture sector for its potential contribution towards alleviating poverty, improving food and nutrition security, reducing youth unemployment and building profitable business ventures, both capture fisheries and aquaculture are gaining increased attention of both the public and private sectors. However, it is ironic that Nigeria still depends on fish importation to meet most of her fish demands despite its associated long coastline bordering the Atlantic Ocean as well as vast fresh and mangrove swamps, creeks, coastal rivers, estuaries, bays, and near and offshore waters. Eight out of the 36 Nigerian states with 25% of Nigeria's total population, share the Atlantic Ocean coastline – a major fishing resource. Yet, national production cannot meet national demand. With the emerging problems in fish captures from the wild, aquaculture began to gain popularity and support through policies, trainings, inputs and finance. Its provision of employment and food fish has been on the increase and in 2015, fisheries' contribution to agricultural GDP rose to 0.88% (FDF, 2018).

In 2013, per caput consumption of fish was estimated at about 13.3 kg which represents an important dietary element and a major source of animal protein available to majority of Nigerians (FAO, 2014). And while marine fish catches contributed 36 percent, inland waters contributed 33 percent and aquaculture 31 percent to the total national production of 1.027million metric tons in 2015.

Owing to recent significant investments of private capital and a renewed political will to empower the private sector in the area of aquaculture development, Nigeria became the largest aquaculture producer in Sub-Saharan Africa and this importance is steadily increasing. Over the past 35 years, aquaculture production in Nigeria has grown 12 percent a year (compared to the world average of 8 percent), from 21,700 tons in 1999, aquaculture production has grown steadily to 316,700 tons in 2015. Catfish, typically grown in ponds and tanks, is the most farmed species in Nigeria, constituting over half of the total aquaculture production by volume (Amosu et al, 2017). Nigeria's aquaculture focuses mainly on freshwater fish, with catfish species accounting for 64 percent of aquaculture production. In 2012, 13,627 people were reported as employed in aquaculture and 2% of this was women (FAO, 2016).

Aquaculture is the fastest growing food-producing sector in the world, contributing one-third of global food fish production. The nutritional benefits of fish consumption have a positive link to increased food security and decreased poverty rates in developing states (FAO, 2014). Catfish and Tilapia species are the common cultivable fishes in Nigeria and though, the population of fishermen engaged in fishing from the wild had increased (though with depleting output) over the years before the COVID-19 pandemic, it was estimated that aquaculture provided direct and indirect employment to over six (6) million people in Nigeria (FAO 2018). Despite this assertion, there have been controversies about the exact population of people involved in aquaculture production and its value chain as well as production figures. According to WorldFish Nigeria Strategy (2018), about 0.35 million producer households would adopt improved breeds, aquafeeds, fish health and aquaculture and fisheries management practices by 2022. It also proposed that 0.19 million people of which 50% would be women will be exited from poverty through improvements in fisheries and aquaculture livelihood programmes. However, it was estimated that over 60% of fish farmers have retired because of high cost of fish feed which takes off the profit they would have

made in rearing fish to table size (FAO, 2020). It is estimated that feeds constitutes about 70 - 80% of total cost of inputs in fish rearing.

Materials and Methods

Materials for the study were extracts of secondary data from existing literatures. The Holt Double Exponential Smoothing method was adopted to extrapolate fish production figure for 2016 to 2019 using 2015 as base. The results of the study are analyzed and presented using descriptive, simple statistics. The HDES method has two characteristics as follows:

1. Holt double exponential smoothing method has two parameters
 - the weighting parameters (the new value is greater than previous observations) and
 - weighted to estimate the trend of data.
2. It has two estimates
 - permanent component (ℓ_{T-1}) estimate of the level of the time series constructed in time period $T-1$ and
 - trend component (b_{T-1}) estimate of the growth rate of the time series constructed in time period $T-1$
3. There are three equations
 - Smoothing

$$\ell_T = \alpha y_T + (1 - \alpha)(\ell_{T-1} + b_{T-1}) \quad \dots\dots\dots 1$$

- Trend estimate

$$b_T = \gamma(\ell_T - \ell_{T-1}) + (1 - \gamma)b_{T-1} \quad \dots\dots\dots 2$$

where α = smoothing constant for the level ($0 \leq \alpha \leq 1$) γ = smoothing constant for the trend ($0 \leq \gamma \leq 1$)

- Point forecast made at time T for y_{T+p}

$$\hat{y}_{T+p}(T) = \ell_T + pb_T \quad (p = 1, 2, 3, \dots) \quad \dots\dots\dots 3$$

Results and Discussions

The percentage share of aquaculture output to total fish production increased steadily as depicted in Table 1, from 8.63% in 2004 to 35.44% in 2019 (over 300% increase). These increases resulted from sustained campaign and assistance to fish farmers through credits and improved fish seeds. Generally, fishery is considered to be one of the most lucrative economic sectors especially in the coastal communities where the majority of the populations are engaged in fishing and fishing related businesses (Abohweyere *et al*, 2004). However, the sub-sector is currently being challenged by high cost of inputs, insecurity in Nigeria's coastal environment and lack of credit and infrastructure facilities. Consequently, aquaculture development has been on steady increase (figure 1) as it is considered to be most reliable and safe in fish production. The steady state is associated with the precarious conditions characterizing capture fisheries as well as the effectiveness of government support in the sub-sector, in recent times. The growing prospect in aquaculture to potentially provide employment and stable income encourages investment and reinvestment in the sub-sector

Table 1: Estimated Fish Production (metric tons) 2004 - 2019

Year	Artisanal	Industrial	Aquaculture	Total	Aqua/Total (%)
2004	434830	30421	43950	509201	8.63
2005	490594	32595	56355	579544	9.72
2006	518537	33778	84533	636848	13.27
2007	504227	26193	85087	615507	13.82
2008	511382	29986	143207	684575	20.92
2009	598211	29698	152796	780705	19.57
2010	616981	31510	200535	849026	23.61
2011	638486	33485	221128	893099	24.76
2012	668754	45631	253898	968283	26.22
2013	744930	59871	278706	1083507	25.72
2014	759828	49952	313231	843011	37.17
2015	694867	15464	316727	1027058	30.84
2016	772102	46674	378174	1196950	31.59
2017	805201	48467	421113	1274781	33.03
2018	838300	50260	464052	1352612	34.31
2019	871399	52053	506991	1430443	35.44

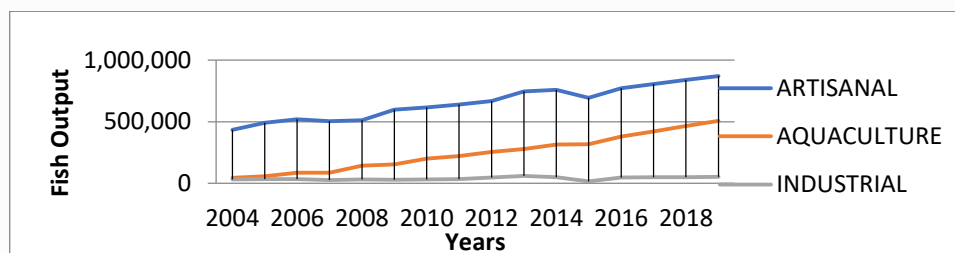


Figure 1: Fish Production (2014 – 2019)

Conclusion and Recommendations

Unemployment has been of concern to the Nigerian government over the years and this is further exacerbated by the COVID-19 pandemic which resulted in the closure of several manufacturing and service industries locally and globally. There are still many uncertainties ahead, particularly with regard to the duration and severity of the pandemic, but a prolonged downturn is likely to introduce long-term transformations to the sectors as some businesses still remain closed despite lockdown eases. It is recognized that the aquaculture fisheries sector is crucial to people's livelihoods programmes and the national economy, embracing impacts on food and employment. Generally, it contributes to the national goals of environmental protection, conservation of biodiversity, socioeconomic development, good governance and poverty alleviation which translate into employment opportunities. The reduction in fish output due to COVID-19 reduced the amount of fish available for processing and trade. This particularly impacted on producers, women and transporters, who are mostly in charge of the activities. Globally, before the pandemic, fish consumption was projected to increase by 30 million tons by 2030 as a result of population increases and improved living standards. Therefore, it is essential that this demand be met through the sustainable growth of aquaculture, which will contribute to the attainment of the United Nations' Sustainable Development Goals (SDGs) targets, such as zero hunger, poverty alleviation and conservation and sustainable utilization of natural resources. Therefore, the potentials to sustain increased aquaculture fish production can be rejuvenated and sustained if the enthusiasm exhibited in the 2005 "Fish for all Summit" which grew Nigeria's aquaculture (cat fish production) between 2005 and 2007 can be simulated. From the foregoing, it is suggested that measures should be put in place to sustain aquaculture. However, cataloguing and inventory study of -sector the sub has become necessary for adequate policy formulation.

References

- Abohweyere P. O., Jim-Saiki L. O., Ogunbadejo H. K., Alhaji T. A. and Adeogun O. A. (2004). Knowledge, Attitude and Practices of Artisanal Fishers towards HIV/AIDS in Nigeria. Field Survey Report, NIOMR, Lagos.
- Amosu A. O., Hammed A. M., Togunde K. A., Joseph O. O. and Adekoya A. (2017). Possible Aquaculture Development in Nigeria: Evidence for Commercial Prospects. *Journal of Agricultural Science and Technology* B7, 194 – 205.
- FishNet Alliance (2020). Covid 19 and Fisheries . www.fishnetalliance.com. Accessed on 20/8/2020
- Food and Agricultural Organization (FAO) 2014, 2016 and 2018 Reports. FAO, Rome.
- Food and Agricultural Organization –FAO (2020). Novel Coronavirus (COVID-19) Report. FAO, R
- National Bureau of Statistics (NBS) 2020 Report.
- National Centre for Disease Control (NCDC) 2020 Report.
- World Bank (2016). Annual Report on Fisheries .
- World Fish Center (2018). World Fish Nigeria Strategy: 2018 -2022, Penang, Malaysia.

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Fish Production and Economic Growth in Nigeria: Implication for Rural Poverty Alleviation

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Abstract

This research provides empirical information on the relationship between fish production and the growth of the Nigerian economy with a focus on poverty reduction. Time series data from 1970 to 2016 were employed and the analyses of the data were done using unit root tests and the bounds Auto Regressive Distributed Lag testing approach to co-integration. The result of the analysis shows that fish production significantly influences Nigeria's economic growth in the long run. Despite the growth poverty is still on the increase and this calls for a shift from a monolithic oil-based economy to a more plural one with fish as a subsector of agriculture being the lead sector. It is recommended that pro-poor policies should be designed for alleviating rural poverty through increased investments in aquaculture development by the public and private sector.

Keywords: fish production, co-integration, Nigerian economic growth, rural poverty

Introduction

Fish is a critical source of animal protein, mineral, and micronutrient supplies in Africa where more than 200 million people are reported to eat fish regularly (Bene, 2015). There are about 20 African countries where fish accounts for more than 20% of animal protein supplies (FAO, 2017). Similar to other continents, Africa has recently experienced a diet transformation toward increasing demand for animal source products such as meat and fish (Tschirley, 2015). Growth in fish consumption was high (at 25–50%) between 2007 and 2015 in most countries in Sub-Saharan Africa (SSA) (Cai, 2017). As observed in other regions, the trend of increasing demand for fish in Africa is driven by population and income growth, and increasing appreciation of health benefits of fish consumption (Thurstan, 2014). Changes in lifestyles and consumer preferences associated with rapid urbanization and globalization are also reported to be positively correlated with increasing fish consumption.

Despite the increasing demand for fish, growth in production of capture fisheries and aquaculture in Africa has been slow (Chan, 2014; OECD/FAO, 2017). Capture fisheries, particularly inland captures represent the most important source of fish supply in many countries in SSA. Nonetheless, overfishing, lack of effective fisheries management, and water and land-use change have caused many fisheries in Africa to decline or stagnate.

Current trends in fish production, consumption and trade suggest that fish is among the most traded food commodities and the trade is playing an increasingly important role to improve the welfare of local and global fish food systems for Nigeria and developing countries (Wang, 2018).

The increasing demand for fish in Africa has also created opportunities for re-inventing African aquaculture development. Recently, there is evidence that aquaculture growth in Africa has speeded up (Kobayashi, 2015). A number of countries in SSA such as in Ghana, Kenya, Nigeria, South Africa, Uganda, and Zambia have experienced rapid growth in commercial aquaculture as a market /demand response (Asiedu, 2016). These emergent trends in aquaculture development have contributed largely to the seven-fold increase in aquaculture production in Nigeria during the last decade, with an average annual growth rate of 21 %. The ongoing transformation in fish supply and its impacts on fish availability, ultimately affect the contribution of fish to food and nutrition security in Nigeria. Hence, much of the future development will depend on policy and decision-makers to provide guidance on how to sustainably valorize existing and emergent opportunities in aquaculture and fisheries and thus to improve the supply of fish to a growing population. This paper seeks to unravel the impact of increased fish production on Nigeria's rural poverty alleviation.

Materials and Methods

This study employed time-series data on the gross of fish production, real gross domestic product, interest rate, exchange rate and inflation rate extending over the period of 1970 to 2016 in Nigeria (see appendix). The mean annual time series data of the selected variables were employed in the study. The data were sourced from the publications of the Central Bank of Nigeria, Annual Reports and Statistical Bulletin and World Bank data and the National Bureau of Statistics (NBS, 2016). The autoregressive distributed lag (ARDL) bounds testing procedure was used to examine the co-integration (long run) relationship between economic growth and its determinants (fish production, interest rate, exchange rate, and inflation rate) as well as the short-run dynamics. The bound test is basically computed based on an estimated error correction version of the autoregressive distributed lag (ARDL) model, by Ordinary Least Square (OLS) estimator (Pesaran et al., 2001).

An F-test of the joint significance of the coefficients of the lagged levels of the variables was used to test the hypothesis of no co-integration among the variables against the presence of co-integration among the variables. The null hypothesis of no co-integration between economic growth, fish production, interest rate, exchange rate and the inflation rate was given as:

$$H_0: \phi_1 = \phi_2 = \phi_3 = \phi_4 = \phi_5$$

The alternative hypothesis was given as

$$H_a: \phi_1 \neq \phi_2 \neq \phi_3 \neq \phi_4 \neq \phi_5$$

The F-test has a nonstandard distribution irrespective of whether the variables are 1(0) or 1(1).

Model Specification

The relationship between economic growth, fish production, interest rate, exchange rate, and the inflation rate is expressed implicitly as:

$$ECG = F (FP, ITR, EXCH, INF) \dots\dots\dots (1)$$

The choice of interest, exchange and inflation rates as explanatory variables is based on economic theory. These variables are monetary policy variables that determine the rate of economic growth. Following Pesaran et al. (2001), the ARDL model specification of equation (1) is expressed as unrestricted error correction model (UECM) to test for co-integration between the variables under study:

$$\begin{aligned} \Delta \ln ECG_t = & \phi_0 + \sum_{i=1}^p \phi_1 \Delta \ln ECG_{t-i} + \sum_{i=1}^p \phi_2 \Delta \ln FP_{t-i} + \sum_{i=1}^p \phi_3 \Delta \ln INT_{t-i} \\ & + \sum_{i=1}^p \phi_4 \Delta \ln EXH_{t-i} + \sum_{i=0}^p \phi_5 \Delta \ln INF_{t-i} + \sum_{i=1}^p \phi_1 \Delta \ln ECG_{t-i} + \sum_{i=0}^p \phi_2 \Delta \ln FP_{t-i} + \\ & \sum_{i=0}^p \phi_3 \Delta \ln INT_{t-i} + \sum_{i=0}^p \phi_4 \Delta \ln EXH_{t-i} + \sum_{i=0}^p \phi_5 \Delta \ln INF_{t-i} + u_t \end{aligned} \quad (2)$$

Once cointegration is established, the long-run relationship is estimated using the conditional ARDL model specified as:

$$\ln ECG_t = \phi_0 + \beta_1 \ln ECG_{t-1} + \beta_2 \ln FP_{t-1} + \beta_3 \ln INT_{t-1} + \beta_4 \ln EXH_{t-1} + \beta_5 \ln INF_{t-1} + u_t \quad (3)$$

The short-run dynamic relationship is estimated using an error correction model specified as:

$$\begin{aligned} \Delta \ln ECG_t = & \phi_0 + \sum_{i=1}^p \phi_1 \Delta \ln ECG_{t-i} + \sum_{i=0}^p \phi_2 \Delta \ln FP_{t-i} + \sum_{i=0}^p \phi_3 \Delta \ln INT_{t-i} + \sum_{i=0}^p \phi_4 \Delta \ln EXH_{t-i} + \\ & \sum_{i=0}^p \phi_5 \Delta \ln INF_{t-i} + \delta ecmt_{-1} + u_t \end{aligned} \quad (4)$$

Where:

ECG = Economic growth is given by real GDP (naira)

FP = Fish production given by gross production in metric tonnes

INTR = Interest rate (per cent)

EXCH = Exchange rate (naira per US dollar)

INF = Inflation rate (per cent)

ϕ_0 = Constant term

u_t = White noise

$\varphi_1 - \varphi_5$	= Short-run elasticities (coefficients of the first-differenced explanatory variables)
$\beta_1 - \beta_5$	= Long-run elasticities (coefficients of the explanatory variables)
ecm_{t-1}	= Error correction term lagged for one period
δ	= Speed of adjustment
Δ	= First difference operator
$\ln$	= Natural logarithm
p	= Lag length

Results and Discussion

Unit Root Test

The unit root test was carried out using the Augmented Dickey-Fuller (ADF) unit root test. The result of the ADF test as shown in Table 1 indicated that LFG, LECG, LINT, and LEXCH were integrated of order one while LINF was integrated of order zero. Therefore, the variables under study are not integrated of the same order and this justifies the use of bounds approach to co-integration over other conventional approaches that require the variables to be integrated of the same order.

Table 1: Result of Augmented Dickey-Fuller Test

Variable Level	ADF Statistic	Test Critical value 5%	Decision
LFP	-0.933371	-2.928142	Non- Stationary
LECG	-0.769322	-2.928142	Non-Stationary
LINT	-1.488214	-2.926622	Non- Stationary
LEXCH	-0.138286	-2.926622	Non- Stationary
LINF	-3.888541	-2.926622	Stationary
Δ LFP	-10.15804	-2.928142	Stationary
Δ LECG	-5.022681	-2.928142	Stationary
Δ INT	-6.588947	-2.928142	Stationary
Δ EXCH	-5.418656	-2.928142	Stationary

Table 2: ARDL Bounds Test for Co-integration

Critical value	Lower bound value	Upper bound value
1%	3.74	5.06
5%	2.86	4.01
Computed F- statistic =4.56		

ARDL Bounds Test for Co-integration

The computed F-statistics; $F_{\ln ECG}(\ln FP, \ln EXCH, \ln INT, \ln INF)$ as shown in Table 2 is = 4.56. This value is above the upper bounds of the critical value of 4.01 at 5% level of significance. This implies that there is co-integration (long-run relationship) between economic growth, agricultural production, interest rate, exchange rate, and inflation rate and therefore, the null hypothesis of no co-integration between the variables is rejected and the alternative hypothesis is accepted.

Computed F-statistic: $F_{\ln ECG}(\ln AGP, \ln EXC, \ln IFR, \ln ITR) = 4.97$

Note: Critical Values are cited from PESARAN et al. (2001), Unrestricted intercept and no trend for K = 4.

The result of the estimated coefficients of the long-run relationship in Table 3 indicates that Fish production has a positive and significant influence on economic growth at 5% probability level. The estimated coefficient of fish production (0.3966) implies that a 1% increase in fish production will increase economic growth by approximately 0.4%, all things being equal. The interest rate had the expected negative sign and significant at 5% probability levels. The inflation rate was found to be positively related to economic growth and significant at 10% with an estimated coefficient of -.037. This implies that a unit increase in the inflation rate will lead to an increase in

economic growth by a magnitude of 0.037. Exchange change rate was found to be positively related to economic growth but not significant at the chosen probability levels of this study.

Estimated Long-Run Relationship

Table 3: Estimated Long Run Coefficients using the ARDL Approach

Dependent variable: LECG				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.274315	1.401262	2.336690	0.0243
LFP	0.396684	0.100702	3.939164	0.0003
LINT	-0.395830	0.092928	-4.259523	0.0001
LINF	0.037164	0.028047	1.325062	0.1923
LEXCH	0.008237	0.032079	0.256785	0.7986

ARDL(1,1,1,0,1) selected based on Akaike info Criterion

Source: Authors computation using E-view 9.0

Estimated Short-Run Relationship

Table 4: Results of the ARDL Short-run Relationship

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003306	0.009678	0.341557	0.7346
D(LECG(-1))	0.482311	0.163739	2.945617	0.0055
D(LFP(-1))	0.071179	0.01156	1.266680	0.2192
D(LINT(-1))	-0.004022	0.066517	-0.060460	0.9521
D(LINF(-1))	0.014528	0.011597	1.252713	0.2180
D(LEXCH(-1))	0.006596	0.034131	0.193250	0.8478
ECT(-1)	-0.476773	0.083373	-2.120280	0.0406
R-squared	0.526223	Mean dependent var		0.005729
Adjusted R-squared	0.504047	S.D. dependent var		0.056211
S.E. of regression	0.053207	Akaike info criterion		-2.887225
Sum squared resid	0.107577	Schwarz criterion		-2.606188
Log-likelihood	71.96255	Hannan-Quinn criter.		-2.782457
F-statistic	4.851622	Durbin-Watson stat		2.222402
Prob(F-statistic)	0.114928			

Source: Authors computation using E-view 9.0

The results of the short-run dynamic coefficients associated with the long-run relationships obtained from the error correction model given in Table 4. The signs of the short-run dynamic interactions are consistent with that of the long-run relationship. The estimated error correction coefficient of -0.476773 (0.0406) is significant, has the correct sign, and imply a fair speed of adjustment to equilibrium after a shock.

Approximately 48% of disequilibria from the previous year's shock converge back to the long-run equilibrium in the current year. Fish production and inflation rate were found to be significant in influencing economic growth at 10% probability levels, respectively. The interest rate was found to be insignificant just as in the case of the long-run relationship. The exchange rate was found to possess similar to the long-run relationship but not significant at the 10% probability level with an estimated coefficient of 0.006596.

Diagnostic Tests

Table 5: ARDL Model Diagnostic Tests

LM Test Statistics		Prob
Serial Correlation	$X^2(1) = 2.876083$	0.0800
Normality	$X^2(2) = 5.438271$	0.8453
Heteroscedasticity	$X^2(1) = 4.824310$	0.5665

The outcome of the Lagrange multiplier test of residual serial correlation, Ramsey's RESET test, Jarque Bera normality test and Heteroscedasticity test as presented in Table 5 indicates the model passed all the tests and this implies that it has a correct functional form, its residuals are serially uncorrelated, normally distributed and homoscedastic.

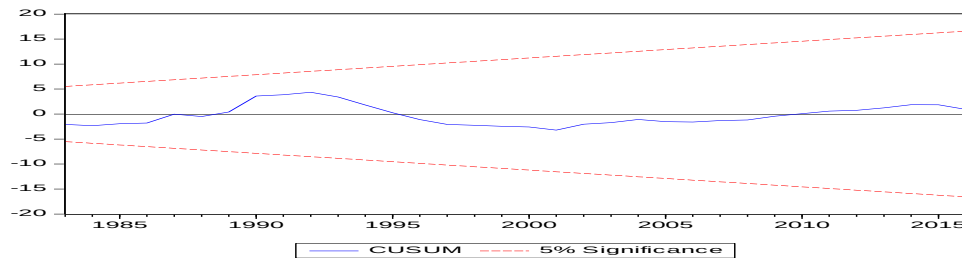


Figure 1: Test result for model stability (CUSUM Test)

The cumulative sum (CUSUM) plots from a recursive estimation of the model are shown in figure 1 respectively. This indicates stability in the coefficients over the sample period as the plot of the CUSUM statistic falls inside the critical bands of the 5% confidence interval of parameter stability.

Conclusion

This paper established that fish production was positively related to economic growth in Nigeria and the relationship was significant both in the long run and in the short run. Key drivers negatively affecting inland capture fisheries in Nigeria include hydropower developments, deforestation, mining, the introduction of invasive species and environmentally damaging fishing gear (Tweddle, 2015). However, the trend in economic growth of Nigeria has not yielded a physical improvement in the well-being of a larger proportion of the population especially among the coastal populace whose primary occupation is fishing. Therefore, an economic growth that translates into poverty reduction, enhanced food security, health status, educational capacity and empowerment of youths and women in rural Nigeria should be embraced. It is recommended that pro-poor policies should be designed for alleviating rural poverty and this should be centered on diversifying the Nigerian economy with fishery a subset of agriculture as the driver of the economy so that the benefits of economic growth will trickle down to the agro-based rural population that constitutes a larger proportion of the population of Nigeria. Therefore, all tiers of government and the private sector should be fully involved in pursuing the course of fish development for the growth of the Nigerian economy and ultimately poverty reduction.

References

- Asche, F., Bellemare, M. F., Roheim, C., Smith, M. D. and Tveteras, S. (2015). Fair enough? Food security and the international trade of seafood, *World Dev.* 67, 151–160, <https://doi.org/10.1016/j.worlddev.2014.10.013>.
- Bene, C. and Heck, S. (2015). Fish and food security in Africa, NAGA, World. *Cent. Q.* 28 (3–4) FAO, FAOSTAT. (2017). Statistics database. Food balance sheets, <http://www.fao.org/faostat/en/#data/FBS> .
- Cai, J. and Leung, P. (2017). Short-term projection of global fish demand and supply gaps, *FAO Fisheries and Aquaculture Technical Paper* No 601. Rome 607.
- CBN (Central Bank of Nigeria) (2014). Annual Report and Statement of Accounts for the Year Ended 31st December 2014. Available at: <http://www.cbn.org.ng>. Accessed 17 August 2019.

- CBN (Central Bank of Nigeria) (2015): Annual Report and Statement of Accounts for the Year Ended 31st December 2015. Available at: <http://www.cbn.org.ng>. Accessed 17 August 2019.
- CBN (Central Bank of Nigeria) (2016): Annual Report for the Year Ended 31st December 2016 Available at: <http://www.cbn.org.ng>. Accessed 17 August 2019.
- Chan, C.Y., Tran, N. S., Pethiyagoda, C. C., Crissman, T. B., Sulser, M. and Phillips, J. (2018). Prospect and challenges of fish for food security in Africa, *Glob. Food Secur.*, 8–13
(http://pubs.iclarm.net/resource_centre/WF_2466.pdf) .
- FAO, Fishery and Aquaculture Statistics,(2018) Global production by production source 1950– 2016 (FishstatJ). In: FAO Fisheries and Aquaculture Department [online]. Rome,
(<http://www.fao.org/fishery/statistics/software/fishstat/en>) .
- Kobayashi, M., Msangi, S. M., Batka, S., Vannuccini, M. M., Dey, J. L. and Anderson, J. L. (2015). Fish to 2030: the role and opportunity for aquaculture, *Aquac. Econ. Manag.* 19 (3) 282–300,
<https://doi.org/10.1080/13657305.2015.994240>.
- OECD/FAO, OECD/Food and Agriculture Organization of the United Nations, (2017). OECD FAO Agricultural Outlook 2017–2026, OECD Publishing, Paris, (https://dx.doi.org/10.1787/agr_outlook-2017-en).
- Pesaran, M. H., Shin, Y. and Smith, R. (2001). Bounds testing approaches to the analysis of level relationships. In: *Journal of Applied Econometrics* 16 (3), 289–326.
- Thurstan, R. H. and Roberts, C. M. (2014). The past and future of fish consumption: can supplies meet healthy eating recommendations? *Mar. Pollut. Bull.* 89 (1–2) 5–11, <https://doi.org/10.1016/j.marpolbul>.
- Tschirley, D., Reardon, T., Dolislager, M. and Snyder, J. (2015). The rise of a middle class in East and Southern Africa: implications for food system transformation, *J. Int. Dev.* 27 (5) 628–646,
<https://doi.org/10.1002/jid.3107>.
- Tweddle, D., Cowx, I., Peel, R. and Weyl, O. (2015). Challenges in fisheries management in the Zambezi, one of the great rivers of Africa, *Fish. Manag. Ecol.* 22 (1), 99–111, <https://doi.org/10.1111/fme.12107>.
- Wang, P., Tran, N., Wilson, N. L., Chan, C.Y. and Dao D. (2018). An Analysis of Seafood Trade Duration: The Case of ASEAN, *Marine Resource Economics*, 2018. <https://doi.org/10.1086/700599>;
(<https://www.journals.uchicago.edu/doi/abs/10.1086/700599>) .

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Assessment of Growth Performance in Tilapia (*Oreochromis niloticus*) and Tomato (*Solanum lycopersicum*) in Aquaponics System

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Abstract

Aquaponics (AP) is a food production system that combines hydroponic (HP) crop production with recirculating aquaculture. The study investigates the growth performance of Tilapia (*Oreochromis niloticus*) and Tomatoes (*Solanum lycopersicum*) in a recirculating Aquaponics system. For this study we have 3 treatments with 2 replicates, the treatments are the aquaponics system, hydroponics system and fish culture system. Fish Culture, this is fish alone that are fed. Hydroponics, in these treatments tomatoes seedlings are planted in a hydroponics system and water is changed regularly and foliage spray is been applied. Aquaponics treatments were the fish and tomatoes are reared in a recirculating system the fish are fed twice a day, the water parameters are determined once a week, the weight and length is also measured, the plant height, length and foliage numbers are also recorded weekly and these was observed for 12 weeks. The initial mean length of the fish culture was 6.1 ± 0.92 cm which increased to 8.4 ± 1.18 cm and the mean weight was 4.5 ± 2.30 g that increased to 8.6 ± 18.60 g while the initial mean length of the fish in aquaponics system was 6.0 ± 0.92 cm which increased to 8.7 ± 1.18 cm and the mean weight was 4.5 ± 2.30 g that increased to 9.23 ± 0.60 g during harvesting time respectively. There was a significant difference ($p=0.01$) in mean length and weight gain of fish among the different sampling dates. The correlation coefficient (r) was 0.97 for tilapia in recirculating aquaponics system. The correlation coefficient in the experiment indicated that the length and weight of fish was strongly correlated and it was close to 1. The result observed from the growth performance considering Aquaponics system and Fish culture showed that the best growth performance was achieved in the aquaponics system for tilapia. In conclusion, growth of the tomato plant differed when stocked in Hydroponics and Aquaponics system, depending upon the nutrient variability. The aquaponics system is better than the hydroponics system in terms of growth performance of tomatoes and tilapia.

Keywords: Aquaponics, Fish Culture, Hydroponics

Introduction

Nigeria still remains Africa's largest frozen fish importer; over 800,000 Metric tons of fish are imported to meet the annual demand, FAO 2009. In FAO Report of 2009, fish production through aquaculture as continued to increase significantly worldwide and tilapia has become the third most important fish in aquaculture after carps and salmonids. Tomato; *Solanum lycopersicum*, in recent years, Nigeria have spent over N11 billion for the importation of processed tomatoes. Aquaponics combines aquaculture and hydroponic plant production in a closed-loop water system that simultaneously grows both plants and fish. In a symbiotic relationship, the waste that is produced by fish in water tanks, which could become toxic for the fish if not cleaned, is used directly or converted by bacteria into useful nutrients for plants (Diver, 2006; Malcolm, 2007). The objective is to study the growth performance of tilapia (*oreochromis niloticus*) and tomato (*solanum lycopersicum*) in aquaponics.

Methodology

The experiment was conducted at the Department of Aquaculture and Fisheries Management, University of Ibadan, Oyo State, Nigeria. The experimental fish that was used for the study was tilapia while the vegetable was tomato. The experiments lasted for twelve weeks. The experimental design for this study was three by two factorial (3by2) having 3 treatments with 2 replicates for each treatment; Treatment FC: - Fish Culture, Treatment HP: - Hydroponics and Treatment AQ: - Aquaponics. The data generated from growth and nutrient utilization, physiological responses and survival rate in the various system combinations was evaluated using Analysis of variance (one-way ANOVA).

Results and Discussion

The observation from the results of the water quality parameters (Figure 1) taken during the period of the experiments is highlighted as follows, the average NH_3 , NO_2 , NO_3 , pH, DO and temperature values for fish culture are within the suitable range of fish culture and Aquaponics system throughout the experiment.

The weekly growth of *Oreochromis niloticus* under different systems are presented in Figure 2. There was a significant difference ($p=0.01$) in mean length and weight gain of fish among the different sampling dates. The mean length gain varied from $6.0\pm0.92\text{cm}$ to $8.80\pm0.82\text{cm}/\text{fish}$. Fish Culture 2 (FC2) gave the highest mean length gain ($8.80\pm0.82\text{cm}/\text{fish}$) while the two aquaponics systems (AQ1 and AQ2) exhibited the least ($6.0\pm0.92\text{cm}/\text{fish}$). There is no significant difference among treatments. The growth rate of tomato in the experiment was within the range of values reported by [Rana et al. \(2011\)](#). These authors stated faster growth of the plant in a closed recirculating aquaculture system

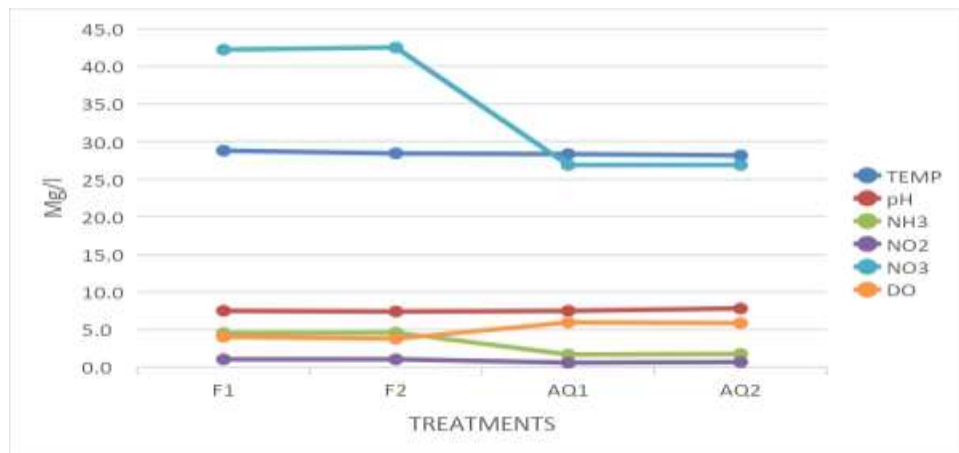


Fig. 1: Water quality parameters of fish reared under different



Fig.2: Weekly growth of *Oreochromis niloticus* under different systems

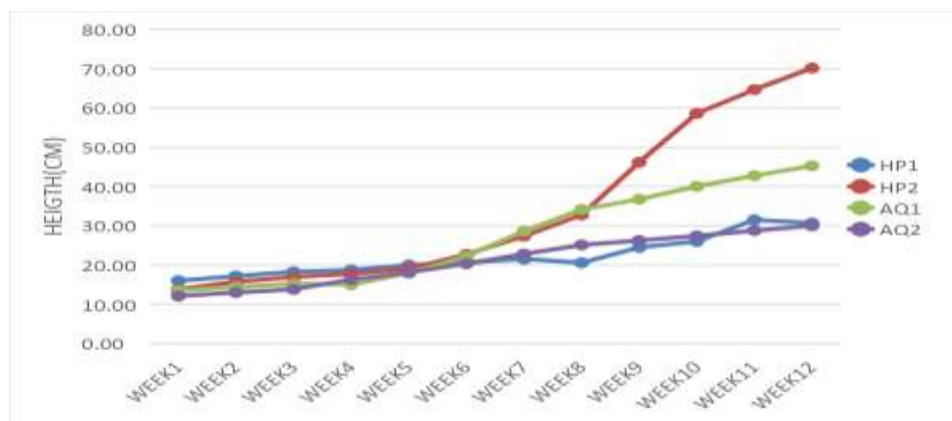


Fig.3: Plant heights observed during study period

Conclusion

The aquaponic system did not adversely affect the growth of Tilapia. Growth of the tomato plant differed when stocked in Hydroponics and aquaponic system, depending upon the nutrient variability. Dynamics of the nutrients in the culture medium was modulated by the nitrification process and general conditions inside the system. Water quality parameters varied due to disparity in nutrient conversion and rate of their uptake by the plants. The outcome from this research is useful for farmers who can implement the system in fish farms, tanks or ponds for creating business opportunities while widening the market for organic plants (vegetables).

References

- FAO 2009. Food for the Cities multidisciplinary initiative: <http://www.fao.org/fcit> October 2009
- Food and Agriculture Organization of the United Nations (FAO). 2009. FAO FishStat plus Aquaculture Production 2002-2009. Rome, Italy. pp: 46.
- Diver, S. 2006. *Aquaponics—Integration of Hydroponics with Aquaculture*. ATTRA—National Sustainable Agriculture Information Service (National Center for Appropriate Technology).
- Malcolm, J. 2007. The Start of an Obsession. Backyard Aquaponics. The No.1 Aquaponics Magazine for the Backyard Enthusiast. Issue 1. Summer 2007. Pg. 4-17

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An Assessment of the Application of Linear Programming in Aquaculture Feed Formulation

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Abstract

This work utilized linear programming to allocate raw materials to competing variables (2mm, 4mm and 6mm) in feeds industry for the purpose of profit maximization. The result of the analysis showed that 9 tones of 4mm, 0 unit of 2mm and 0 unit of 6mm should be produced respectively in order to make a profit of about N349,650. The analysis also showed that only the 4mm variable contributes effectively to the profit and the marginal prices of the surplus resources (2mm and 6mm) were zero. This implies that there is no economic advantage in allocating more of that resource, while a unit increase in the other resources will lead to a corresponding increase in the objective value to the tune of the marginal price.

Keywords: Linear programming model, Decision variables, Economic advantage, Profit maximization.

Introduction

Linear programming is technically a mathematical procedure for obtaining a value-weighting solution to a set of simultaneous equations (Patrick and Schaible, 1980). It was first put into significant use during World War II when it was used to determine the most effective way of deploying troops, ammunitions, machineries all of which were scarce resources. The feed formulation model seeks the optimum combination of available feed ingredients that will satisfy the nutritional requirements of the animal at the least possible cost. The model has to satisfy a set of constraints on nutritional levels, availability restrictions, special ingredients required and fund constraints. The technique is highly maneuverable and the nutritionist should take full advantage to investigate the varied types of alternatives for deciding on the best scheme for implementation as the industry faces a lot of challenges.

Production planning problem is one of the most important application of optimization tools using mathematical (linear) programming (Mula *et al*, 2005). There argument centered on sensitivity analysis. According to Waheed et al (2012) linear programming models are frequently used in operation research and management sciences to solve specific problems concerning the use of scare resources. Igwe *et al* (2011) reported that linear programming is a relevant technique in achieving efficiency in production planning, particularly in achieving increased agricultural productivity. However, the general deterministic model is a gross margin maximization model designed to find out the optimum solutions and the decision variables for the model are numbers of hectares the farmer devoted to the production of crop and combination of crop or livestock capacity produced by the farmer.

Materials and Methods

Data used for this paper were obtained based on market surveys for fish feed ingredients carried out in Lagos State between 2009 and 2017. Survey materials included structured questionnaires and oral interviews. Respondents were purposefully selected due to certain socio-economic considerations. The feed formulation model seeks the optimum combination of available feed ingredients that will satisfy the nutritional requirement of the cultured fish at the least cost possible. A linear programming problem with “m” constraints can be mathematically modeled as presented by (Taha [1975], Zeleny, [1982], and Winston, [1995]: Maximize $Z = c_1x_1 + c_2x_2 + \dots\dots\dots c_n x_n$

$$\begin{aligned} \text{Subject to (s. t.)} \quad & a_{11}x_1 + a_{12}x_2 + \dots\dots\dots + a_{1n}x_n \leq b_1 \\ & a_{21}x_1 + a_{21}x_2 + \dots\dots\dots + a_{2n}x_n \leq b_2 \\ & a_{m1}x_1 + a_{m2}x_2 + a_{mn}x_n \leq b_m \\ & x_j \geq 0, j = 1, 2, \dots\dots\dots, n \end{aligned} \quad (2.1)$$

$$\begin{aligned} \text{This can be written as: Min. } Z &= C^t X; \text{ Subject to } AX \leq b. \\ X &\geq 0 \end{aligned} \quad (2.2)$$

Results and Discussion

Interpretation of the LP solution

The optimal plan level was N349,650.00 profit by producing 9 tonnes of 4mm of feeds. Forcing any of the 2mm and 4mm feed enterprise not included in the optimal plan into the programme would lead to reduction in programme value, and by implication, the net annual return the farmer would earn. The marginal opportunity cost of capital (MOC) reported in Table 4 measures how much the programme value will reduce if any of the non-basic activities which erstwhile did not enter the programme, is forced into it. It can be observed that the marginal prices of the surplus resources (2mm and 6mm) are zero. This implies that there is no economic advantage in allocating more of those resources, while a unit increase in the other resource will lead to a corresponding increase in the objective value to the tune of the dual price. For instance, a unit increase in the total quantity of feed produced will increase the objective value by N21,138.00 within the stated range of $27195. \leq \text{RHS} \leq \infty$. However, it is important to note that the marginal prices will remain applicable for simultaneous changes that keep the solution feasible, even if the changes violate individual ranges (Taha, 2007).

The sensitivity analysis of the plan to changes in some production variables was observed. It would be worth changing the production plan only if the revenue were to go beyond these limits. This information on permissible net revenue changes was used to assess the stability of the optimum plan and large ranges indicate a much more confident plan. From Table 1, the difference between the present net revenue figure and the lower limit was large, indicating that the activity was relatively overpriced.

Table 1: Optimal output of LP Model

Variables no/ Names	Solution	Opportunity Cost
1 X ₁	0.0000	21138.0000
2\ X ₂	9.0000	0.0000
3 X ₃	0.0000	15925.0000
4 S ₁	0.0000	3885.0000
5 S ₂	498.0000	0.0000
6 S ₃	695.0000	0.0000
7 S ₄	925.0000	0.0000
8 S ₅	710.00000	0.0000
9 S ₆	100.5000	0.0000
10 S ₇	52.0000	0.0000
11 S ₈	17.0000	0.0000
12 S ₉	16.7000	0.0000
13 S ₁₀	4.2500	0.0000
14 S ₁₁	5.7000	0.0000
15 S ₁₂	3.4000	0.0000
16 S ₁₃	155.000	0.0000

Table 2: Output Result for Sensitivity Analysis of the Objective Variable Coefficient

C<j>	Min. c<j>	Original	Max c<j>
C<1>	Infinity	6057.0000	27195.0000
C<2>	infinity	26600.0000	38850.0000
C<3>	Infinity	34580.0000	50505.0000

Table 3: Sensitivity Analysis for RHS

B<i>	Min. B<i>	Original	Max. B<i>
B<1>	0.0000	90.0000	298.0000
B<2>	126.0000	624.0000	Infinity
B<3>	180.0000	875.0000	Infinity
B<4>	225.0000	1150.0000	Infinity
B<5>	180.0000	890.0000	Infinity
B<6>	27.0000	127.5000	Infinity
B<7>	22.5000	74.5000	Infinity
B<8>	4.5000	21.5000	Infinity
B<9>	4.5000	21.2000	Infinity
B<10>	1.3500	5.6000	Infinity
B<11>	1.8000	7.5000	Infinity
B<12>	0.9000	4.3000	Infinity
B<13>	45.0000	200.0000	Infinity

Conclusion and Recommendation

The decision variables in this research work are the three different sizes of fish feed (2mm, 4mm and 6mm) produced by Solace Feed Limited. The researchers focused mainly on 13 types of ingredients (flour, noodles waste, maize, salt, gnc, fish meal, blood meal, dcp, soya beans meal, fish premix, lysine, vitamin c and toxin binder) used in the production and the amount of each required (feed size). The result shows that 9 tons of 4mm, 0 unit of 2mm and 0 unit of 6mm respectively should be produced and will generate (maximize) profit of N349,650.00.

Based on the result of the analysis, it is profitable to continue to produce the three sizes of feed (2mm, 4mm and 6mm) in order to satisfy her customers. Also, more of the 4mm feeds should be produced in order to maximise profits. Therefore, It is recommended that LP should be applied in the determination of profit maximization levels especially by companies engaged in product-mix. This will assist them in minimizing total cost of production.

References

- Adeyosoye, E. (2012). Profit Maximization in a Product Mix Company Using Linear Programming. *European Journal of Business and Management*, Vol. 4, No. 17.
- Igwe, K.C., C. E. Onyenweaku and J. C. Nwaru (2011). Application of Linear Programming to Semi-commercial Arable and Fishery Enterprises in Abia State, Nigeria. *International Journal of Economics and Management sciences* vol. 1, no. 1.
- Mula, J., Poler, R., Garcia-Sabater, J. P. and Lario, F.C. (2005). Models for Production Planning under Uncertainty. *International Journal on Production Economics*.
- Olorunfemi, T.O.S., F.M. Aderibigbe, S.O. Falaki, O.T. Adebayo and E.A. Fasakin, (2001). An Overview of Linear Programming Application to Least-cost Ration Formulation in Aquaculture. *J. Techno. sci.*, 5: 84-92.
- Patrick, H. and P.J. Schaible, 1980. Poultry: Feed and Nutrition. 2nd Edn., AVI Publishing, USA.,pp: 417-458.
- Taha, H. A. (2007). Operations Research: an Introduction. 8th Ed. Pearson Education, Inc., USA.
- Taha, H. A. (1975). Integer Programming; Theory, Applications and Computations. Academic Press, New York.
- Taha, H.A., 1987. Operations Research. 4th Edn., Macmillan Publishing Co., USA., Pages: 876.
- Waheed BabatundeYahya, Muhammed Kabir Garba, Samuel Oluwasuyi Ige and Adekunle Zeleny, M. (1982). Multiple Criteria Decision-making. McGraw Hill Book, New York.

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The Effect Ofwater Physico-Chemistry On Macrophytes Diversity In Oil Polluted Kpean River, Rivers State, Nigeria

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Abstract

The effect of water physico-chemical properties on macrophytes in oil polluted Kpean River was examined to establish the effects of pollution on macrophytes diversity, species evenness and richness in the river. Watersamples were collected from four stations with sampling bottles and analyzed using standard methods. Macrophytes were manually collected in polythene bags and transported to University of Port Harcourt herbarium for taxonomic identification. The results showed pH range of (7.79 ± 0.31 – 8.62 ± 0.24), Salinity (0.03 ± 0 – 3.25 ± 0.56), Temperature (27.17 ± 0.58 – 27.2 ± 0.69), Dissolved Oxygen (4.13 ± 0.65 – 5.07 ± 0.76), Total Suspended Solids (5.0 ± 4.36 – 14.7 ± 8.14), BOD (15.0 ± 2.65 – 16.2 ± 3.36), and COD (18.37 ± 8.20 – 27.37 ± 2.47). A total of 53 macrophytes specimens belonging to 4 families, 9 genera and 11 species were collected. The family Nymphaeaceae was dominant having 5 species (45.5%), Commelinaceae 3 species (27.3%), Cyperaceae 2 (18.2%) and Pontederiaceae having 1 species (9.0%). Station Two had the highest Relative Abundance (32.07%), followed by Station three (24.53%), Station four (24.53%) and Station one (18.87%). Species diversity was in the order of stations Two (2.256) > One (1.833) > Four (1.585) > Three (1.473). Species Richness was in the order of station Two (5.65) > Four (4.69) = Three (4.69) > One (3.91). The low mean DO and high COD (4.8 and 21.9 respectively) resulted from oil pollution. There were negative correlations between temperature (-0.073075234), COD (-0.734399499), TDS (-0.39495398), conductivity (-0.385296171) and macrophyte diversity; implying that increase in these parameters result in decrease in macrophytes diversity.

Key words: Water quality, aquatic plants, crude oil, correlations

Introduction

Macrophytes are indeed an important community in any water body as the role played undoubtedly include habitat regulation, as well as enhancing most life processes in the water. They support animal species found in the water in many ways and may suffer decline due to pollution from oil. Macrophytes are autotrophs belonging to the primary producers in the aquatic food chain. They regulate and promote life in water by providing physical structure, increase habitat complexity and heterogeneity, and affect various organisms like invertebrates, fishes and water birds (Jack *et al.*, 2005). These functions of macrophytes may not be effective due to alterations caused by pollution of several kinds ranging from anthropogenic activities to oil spill pollution which is the most predominant type that can speedily affect the macrophytes diversity, evenness and richness of any given water body. Oil spills in the Niger Delta have been a regular occurrence, and the resultant degradation of the surrounding environment has caused significant tension between the people living in the region and multinational oil companies operating there. It is important for environmental groups, the federal government, and the foreign oil companies operating in the area to commence mitigating the impacts of spills (Osuji and Nwankwo, 2015). Oil spills in Ogoni has affected both areas where exploration took place, and where none had even occurred. For example, samples from Luawii in Ogoni, where there had been no oil production had 18×10^{-6} ml of hydrocarbons in the water, 360 times higher than the level allowed in drinking water by the European Union (EU) (Ekpenyong and Udofia 2015). Kpean River is found in Ogoni land which is one of the prominent areas in the Niger Delta region, and has been the site of oil industry operations having several oil wells since the late 1950s (Yakubu, 2017). Oil spill pollution that impact macrophytes also affect aquatic zooplanktons that use them for some purposes (Aboyeji, 2013).

Some of the roles played by these aquatic macrophytes include water purification, nutrient recycling, and refuge for zooplankton, fish, cover for a wide range of invertebrates, food source, spawning area, etc. (Cowx and Welcomme, 1988). Macrophytes are large conspicuous plants that are found growing in water bodies that aid in primary production as well as enhancing the existence of zooplankton that solely or indirectly depend on them. They are seen in three forms according to their growth pattern and can be grouped as emergent, submerged or floating; with

examples including water hyacinth, duckweed and cattails (EPA, 2012). Oil spills have been known to affect macrophyte diversity (Inari *et al.*, 2016). Diversity is a measure that combines the number of species in a community and their relative abundances compared with one another. Also, the relative abundances of species in a community compared with one another (evenness) and the number of species in a community (richness) are all affected by changes in physico-chemical properties of the water.

Kpean River is one of the polluted rivers in the Niger Delta region (UNEP 2011), whose physico-chemical parameters are altered by oil pollution directly or indirectly and in turn affect the macrophytes. The parameters affected are biochemical oxygen demand (BOD), dissolved oxygen (DO), chemical oxygen demand (COD), pH, temperature, total suspended solids (TSS), total dissolved solids (TDS) and salinity. All these parameters have their independent effect on the productivity of any water body, as their alteration affect fish population as well as macrophyte survival. The physical and chemical properties of water immensely influenced the composition, distribution and richness of the aquatic macrophytes (Unanam and Akpan, 2006). Some other parameters like DO is one of the most important parameters. Reduced DO indicates polluted water (Vikal, 2009). There had not been any study conducted in Kpean river, to determine the effect of the physico-chemical properties of the water on macrophytes diversity, evenness and richness. Whereas, macrophytes are a source of income, shelter and food for the people of Kpean, the effects of Kpean river physico-chemical properties on the diversity, evenness and species richness of its macrophytes are uncertain.

Generally, this study examined the effect of some physico-chemical parameters on macrophytes in Kpean River. Specifically, it determined the physico-chemical parameters of Kpean River, the distribution and abundance of macrophytes and the relationship between the physico-chemical properties and macrophytes diversity, evenness and its species richness in the Kpean river.

Materials and Methods

Kpean River is in Ogoni at Latitude 4° 37' 00'' and Longitude 7° 27' 00'' in Rivers State, southern Nigeria. The primary occupations of the people are subsistent farming and artisanal fishing.

Collection of water Samples

Samples were collected twice monthly from June to August 2018. Four sampling stations were mapped out and labelled 1 to 4. Station number four was the closest to an oil-well.

The water samples were collected in sterilized labeled bottles and the standard procedure for collection was followed (APHA, 2012). Samples were transported to the laboratory for analysis.

Physico-chemical properties

The physico-chemical properties of water directly or indirectly affect water quality and its suitability for distribution of plants and animals found in them (Obot *et al.*, 2014). These parameters are as follows:

pH: The pH was determined in-situ with a multi-meter (Ultra meter II 6PFC). The equipment was rinsed five times with the sample solution to ensure that only the sample was in the meter. The meter was switched on and the pH reading was taken. The Ultra meter was calibrated with sensor storage solution. The same was repeated in triplicates and the values recorded.

Dissolved Oxygen (DO): the Winkler' method was used for the determination. This was measured in-situ with the JPB 607A Dissolved oxygen Analyzer. The DO analyzer was stabilized for 10 minutes and the probe of the Analyzer was inserted 10-15 cm inside the water containing the test solution. The Analyzer was switched on and the DO reading was taken when the reading became stable. The same was done in triplicate and the values recorded.

Biochemical Oxygen Demand (BOD): The 5 days BOD test method was used in the determination of the biological oxygen demand in accordance with (APHA, 1998).

Total Suspended Solid (TSS): these represented the large particles in the collected and examined water samples. Their quantity was determined by passing a known volume of water sample through a glass fiber filter apparatus, the dried residue on the paper was then weighed.

$$TSS \left(\frac{mg}{l} \right) = \frac{\text{Mass of the residue}}{\text{Volume of sample filtered}}$$

Temperature: Temperature was measured in-situ with the sample in the multi-meter water checker, (Ultra Meter II 6PFC). The temperature button was switched on and the values recorded. It was repeated three times and the mean was recorded.

Total Dissolved Solid (TDS): The same procedure used for determination of temperature parameter above was used in determining the total dissolved solid, with the use of a multi-meter water checker, (Ultra Meter II 6PFC).

Salinity: This was measured in parts per thousands (ppt). Salinity was measured using the SPER BENCH-TOP WATER QUALITY METER (860033 MODEL). The probe of the meter was inserted into a beaker containing the test solution and the meter was switched on and allowed to stabilize for 10 minutes. The salinity reading was taken when it became stable.

Chemical Oxygen Demand (COD): This was analyzed using the COD digester, and the formula:

$$COD \left(\frac{mg}{l} \right) = \frac{b - a \times \text{ml of ferrous ammonium sulphate} \times 1000 \times 8}{\text{ml of sample}}$$

Where, a = ml of titrant with sample

b = ml of titrant with blank

Macrophyte: Macrophytes were collected in plastic bags and conveyed to University of Port Harcourt Herbarium. Identification and classification of the macrophytes were done at the University of Port Harcourt Herbarium (Wood, 1975).

2.3 Statistical Analysis

The water parameters were subjected to one-way ANOVA using the Excel software in analyzing the data at a significance level of (p<0.05).

For the macrophytes several tests were used to determine their composition, diversity and their richness using the Shannon – Wiener diversity index (1963).

$$H = -\sum((Pi) \times \ln (Pi))$$

RESULTS

Physico-chemical properties

The result for the pH ranged within 7.51- 8.87 and a mean of 8.015(Table1). The minimum mean of the pH was 7.79 ± 0.31 and the maximum pH range recorded as 8.62 ± 0.24. The high pH was seen in station 4 in the first month of sampling, with the lowest recorded in station 3 in the same first month. From the pH range, the water is slightly alkaline. There was no significant difference between the stations at p<0.05.

Table 1: Range, Mean And Standard Deviation Of Physicochemical Parameters of The Different Stations

PARAMETER/ RANGE	STATIONS				Mean of Kpean River
	1 Range and mean ± SD	2 Range and mean ± SD	3 Range and mean ± SD	4 Range and mean ± SD	
pH	7.59-8.20 7.81 ± 0.34	7.60-8.15 7.84 ± 0.28	7.51- 8.20 7.79 ± 0.31	8.40- 8.87 8.62 ± 0.24	8.0
Conductivity(µs/cm)	3.61-7.35 5.48 ± 1.87	3.12-7.17 4.48 ± 2.33	3.33-5.17 4.53 ± 1.19	3.30-55.80 37.67 ± 29.78	13.0
TDS (mg/L)	2.75-3.68 3.06 ± 0.54	1.57-3.58 2.48 ± 1.02	2.30-3.40 2.85 ± 0.55	26.5-27.80 27.1 ± 0.66	8.9
Salinity(ppt)	2.87-3.89 3.25 ± 0.56	1.60-3.78 2.39 ± 1.21	2.38-2.99 2.62 ± 0.32	0.03-0.03 0.03 ± 0	2.1
Temperature (°C)	26.5-27.50 27.17 ± 0.58	26.5-27.60 27.2 ± 0.61	26.5-27.50 27.2 ± 0.61	26.4-27.60 27.2 ± 0.69	27.2
DO (mg/L)	4.4-5.90 5.07 ± 0.76	3.8-6.10 4.93 ± 1.15	4.0-5.60 4.9 ± 0.82	3.5-4.80 4.13 ± 0.65	4.8
TSS(mg/L)	7.0-20.0 11.7 ± 7.23	9.0-11.00 14.7 ± 8.14	7.0-8.00 5.0 ± 4.36	5.0-16.00 11.0 ± 5.57	10.6
BOD(mg/L)	13.0-18.0 15.0± 2.65	14.0-17.6 16.2 ± 1.93	13.6-20.0 16.2± 3.36	12.0-21.0 15.73± 4.69	15.8
COD (mg/L)	13.0-28.1 18.7± 8.20	12.0-28. 18.37±7.82	20.5-26.20 23.07± 2.89	25.1-30.00 27.37± 2.47	21.9

The pH of a water body is one factor that indicates the quality of such environment, they have the ability of influencing both biological and chemical processes and their alteration is as a result of pollution which makes it more acidic and such is not good for effective production in the water body. The value for pH shows no significant difference at ($p < 0.05$) but supports the activity of fish and other aquatic life including macrophytes. The recorded pH is like research of Ajibare (2014) who recorded a pH of 7.58, and within WHO standard (6.5-9.5). The result for the conductivity ranges within 3.12µs/cm- 55.80 µs/cm and it has a mean conductivity of 13.0 (Table 1). The minimum mean conductivity was seen in station four (4.48 ± 2.33) and the maximum mean value was seen in station one (37.67 ± 29.78) from (Table 1). The lowest conductivity was recorded in station 1 and highest found in station 4 at first week of sampling.

Conductivity is an index of the total ionic content of water, and therefore indicates freshness or otherwise of the water as it increases with respect to the salinity of water. Fresh water has lower salinity as well as the conductivity level. The mean conductivity of Kpean River was recorded at 13.0 which indicate the water is a fresh water having a salinity mean of 2.1. The result for total dissolved solids (TDS) shows a range of 1.57-27.80 with a mean TDS being 8.9 as shown in (Table 1). The minimum mean of TDS was observed in station two (2.48 ± 1.02) and the maximum mean was found in station four (27.1 ± 0.66).

Total dissolved solid (TDS) is an important parameter in polluted water that shows all ions which are present in it. The value for total dissolved solid was relatively low which is an indication that the water is polluted. The mean value of TDS in Kpean River was 8.9 mg/l which was lesser than the WHO standard (500 mg/l).

The result of salinity ranged from 0.03-3.89ppt with the mean being 2.1ppt (Table 1). The range for the salinity observed was in the order; STN (4) < STN (2) < STN (1) and STN (3).

The temperature value ranges between 26.4°C to 27.60°C having a mean temperature of 27.2. Mean temperature range falls within minimum of 27.17 ± 0.58 to a maximum mean value of (27.2 ± 0.69) as shown in (Table1). There was total reduction in temperature during the second sample with station 4 having the lowest temperature range. The mean temperature of Kpean River was seen to be 27.2 and it indicates that the temperature of the water can support life of both plants and other organism found in them. They show significant difference across the four stations. Emuedoet *al.* (2014) reported a temperature of 29.81°C.

The result for mean dissolved oxygen was 4.8 the range 3.5mg/l and 4.4mg/l respectively and the mean within $(4.13 \pm 0.65 - 5.07 \pm 0.76)$ as shown in (Table1 and figure 6). The dissolved oxygen for the different stations was seen from STN 1(5.07 ± 0.76), STN 2 (4.93 ± 1.15), STN 3 (4.9 ± 0.82) AND STN 4 (4.13 ± 0.65). The lowest dissolved oxygen was recorded in stations 4 in both first and second week of sampling where there was fewer macrophytes. The value for dissolved oxygen was similar with research reported in earlier studies such as 4.49mg/l by Dienne and Woke, (2015) and 4.43mg/l (Ekpenyong and Udofia, 2015). The mean dissolved oxygen 4.8 recorded in this study was lesser than the WHO standard of >6. The result for total suspended solid as examined falls within the range of 5.0 to 9.0, and having a mean TSS of 10.6 (Table 1). Station 2 in the second week of sampling has the highest suspended solid, with its absence in station 3 at the same second week of sampling.

The result for the mean Biological Oxygen Demand was 15.8 seen to be within the range 12.0mg/l - 14.0mg/l, this has a minimum mean value within $(15.0 \pm 2.65 - 16.2 \pm 3.36)$ which is the maximum range for the stations as in (Table 1). The highest BOD was recorded in station 4 in the first week of sampling but reduced at the second time of sampling. Biological oxygen demand (BOD) is the measure of how much oxygen is required for biological processes and metabolism to occur and its increase, or decrease is associated with the dissolved oxygen present in the aquatic system. The mean BOD level of 15.8 mg/l was like other work done in the same area by Ekpenyong and Udeme (2015), and is above the (WHO) standard of 5 mg/l. The high demand is attributed to the presence of both bacteria and fungi, competing for the available dissolved oxygen present.

The result for the Chemical Oxygen Demand showed a mean COD of 21.9 was seen to fall within 12.0 to 25.1, and they have a minimum mean of (18.37 ± 8.20) to maximum mean of (27.37 ± 2.47) for the different stations as seen in (Table 1). The stations with their corresponding mean are STN 1 (18.7 ± 6.70), STN 2 (18.37 ± 7.82), STN 3 (23.07 ± 2.89), and STN 4 (27.37 ± 2.47). The lower COD was recorded in the first week of sampling and seen in station 2 and with the highest in station 4 for both first and second week of sampling. Chemical oxygen demand is an important parameter in polluted water, as there is need for chemical processes to be carried out by animals found in the water body. The mean COD of Kpean River was 21.9 which were above the WHO standard for organism and plant to thrive.

Macrophytes

A total of 11 species of macrophytes belonging to four taxonomic classes were recorded from the Kpean River during cause of the study. Other researcher in the region reported that six (6) aquatic macrophytes were recorded within the non-saline water of the Niger Delta region of Nigeria (Oyedeji and Abowei, 2012). A checklist that shows the identified macrophyte species are shown in (Ta.2). The total number of each species found in each of the stations was calculated for percentage composition and the percentage abundance as shown in (Table 3, Table 4 and Table 5 respectively).

Table 2: The Species Diversity, Species Evenness and the Species Richness of macrophytes found in Kpean River.

	Station 1	Station 2	Station 3	Station 4
Species Diversity	1.833	2.256	1.473	1.585
Evenness	0.79	0.797	0.58	0.62
Richness	3.91	5.65	4.69	4.69

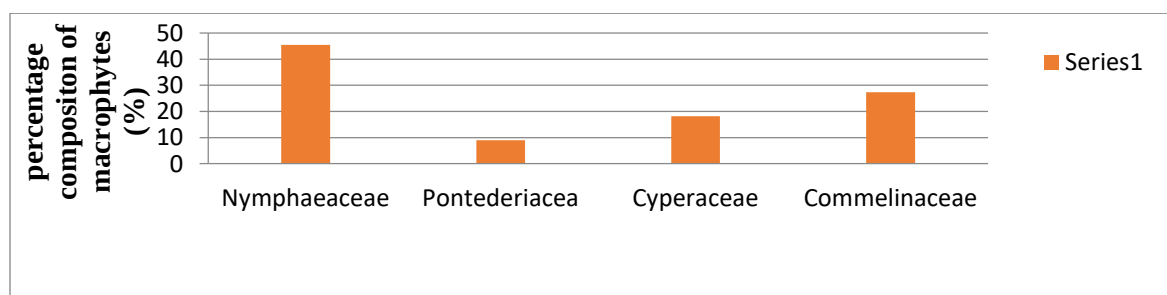
The composition of macrophytes in Kpean river were collected and from the identification, it was seen that station two (2) has the highest in term of both species' diversity, evenness and in the richness of the total species identified.

The family Nymphaeaceae having five species is the most dominant family in the water body.

The river is dominated by *Rhynchosporacorymbosa* being the most dominant species present, and the overall recorded in station 2 as having the most species.

Table 3: Percentage composition of families and species in each class of macrophytes

Class	Total number of family	Total number of species	Percentage composition of species
Nymphaeaceae	1	5	45.5%
Pontederiaceae	1	1	9.0%
Cyperaceae	1	2	18.2%
Commelinaceae	1	3	27.3%
Total	4	11	100%

**Figure 10: Percentage Composition of macrophytes family in Kpean River.**

Correlations between river water physico-chemical parameters and macrophyte diversity, evenness and species richness.

The relationship between the selected physico-chemical parameters and species diversity, species evenness and species richness are shown in table 3.4. There was a strong positive correlation between pH and macrophyte diversity, evenness and richness with correlation coefficient of 0.998629137, 0.819548872 and 0.642851204

respectively. Conductivity however, had a weak and negative correlation coefficient -0.385296171, -0.441983448 and -0.066121161 for macrophyte diversity, evenness and richness respectively.

Similarly, TDS was negatively correlated with coefficient of -0.39495398, -0.456210281 and -0.061726693 for macrophyte diversity, evenness and richness respectively. Salinity had weak correlation with macrophyte diversity, evenness and negatively correlated with species richness having correlation coefficient of 0.293900771, 0.491019779 and -0.203772485 respectively. Dissolved oxygen had positive and weak correlation (0.3934 and 0.5415) for macrophyte diversity and evenness but negatively correlated (-0.0860) with species richness. Total suspended solids (TSS) correlation coefficient was 0.86103599 and 0.825576019 for species diversity and evenness respectively being positive and strongly correlated while 0.354484749 for macrophyte richness was positive and weak. Likewise, BOD has a weak positive correlation (0.081312887 and 0.834943776) with macrophyte diversity and macrophyte species richness respectively, whereas, macrophyte evenness had a negative correlation coefficient (-0.394866829).

COD was, however, negatively correlated with coefficient of -0.734399499, -0.840925063 and -0.098047206 for macrophyte diversity, evenness and richness respectively. Similarly, temperature had negative correlation with macrophyte diversity and evenness but positively correlated with macrophyte richness with correlation coefficient of -0.073075234, -0.550436747, and 0.77220082 respectively.

CONCLUSION

The implication of the negative correlation between temperature and macrophytes is that increase in temperature results to decrease in species diversity and evenness. Other physico-chemical properties with similar negative correlations with macrophyte diversity were COD, TDS and conductivity. Rise in salinity and dissolved Oxygen decreased species richness. Positive correlation means that increase in the physico-chemical parameters within acceptable limits result in corresponding increase in macrophyte diversity, species evenness and richness. Increase in pH and TSS lead to increase in macrophyte diversity, species evenness and richness. However, rise in salinity and dissolved oxygen favoured macrophyte diversity and evenness while rise in BOD and temperature favoured macrophyte species richness.

References

- Aboyeji, O.O. (2013). Freshwater Pollution in Some Nigerian Local Communities, Causes, Consequences and Probable Solutions. *Academic Journal of Interdisciplinary Studies* 2 (13): pp. 111-116.
- Ajibare A. O. (2014). Assessment of Physico-Chemical Parameters of Waters in Ilaje Local Government Area of Ondo State, Nigeria. *International Journal of Fisheries and Aquatic Studies* 1(5): pp 84-92.
- American Public Health Association (APHA) (1998). Standard Method for Examination of Water and Waste APHA 20th Edn. Washington D.C. McGrawHill.
- APHA (2012). Standard Methods for examination of water and wastewater. 22nd ed. Washington: *American Public Health Association*, pp. 1360.
- Cowx, I. G. and Welcomme, R. L. (1988). Rehabilitation of rivers for fish. Oxford: Fishing News Books, Blackwell Science. Pp. 260.
- Dienye H.E. Woke G.N., (2015). Physico-chemical Parameters of the Upper and Lower Reach of the New Calabar River Niger Delta. *Journal of Fisheries & Livestock Production* 3:154. doi:10.4172/2332-2608.1000154.
- Ekpenyong, N. S., & Udofia, U. S. (2015). Oil Pollution and Its Impact on Water Quality in Ibeno Community. *Studies in Sociology of Science*, 6 (2), pp 8-12. DOI: <http://dx.doi.org/10.3968/6398>.
- Emuedo A.O., Anoliefo G. O and Emuedo C. O., (2014) oil pollution and water quality in Niger-Delta: implications for the Sustainability of the Mangrove Ecosystem, *Global journal of Human-social science*, 14(6):pp. 8-16.
- EPA(2012). Water Quality Standards Handbook: Second Edition. EPA-823; Retrieved from <http://water.epa.gov/scitech/swguidance/standard/handbook/index.cfm>.
- Inari H., Ari J. and Riikka V. (2016). Species and habitats in danger: estimating the relative risk posed by oil spills in the Northern Baltic Sea. *Ecosphere* 7(5). <https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/ecs2.1344>
- Jack I.R, Fekarurhorho J.K, Igwe F.U. and Okorosaye O.K. (2005). Determination of total hydrocarbon levels in some organisms from some towns within River State in Nigeria. *Journal of Applied Science and Environmental Management*, 9(3): pp. 59-61.

- Margalef, R., (1958). Temporal succession and spatial heterogeneity in phytoplankton. In: Perspectives in Marine biology, Buzzati-Traverso (ed.), Univ. Calif. Press, Berkeley, pp. 323-347.
- Obot, O.I., Ekpo, I.E and Esua, E.F. (2014). Physicochemical parameters and macrobenthos of Edisne stream, Akwa Ibom State, Nigeria. *American Journal of Biology and life Sciences*, 2(5):pp. 112-121.
- Yakubu, O.H. (2017). Addressing Environmental Health Problems in Ogoniland through Implementation of United Nations Environment Program Recommendations: Environmental Management Strategies. *Environments*, 4, (28): doi:10.3390.
- Osuji S. O. and Nwankwo. E. (2015). Effect of crude oil contamination on the compressive strength of concrete. *Nigerian Journal of Technology (NIJOTECH)*, 34 (2): pp. 259 – 265.
- Vikal, P. (2009), Multivariant analysis of drinking water quality parameters of lake Pichhola in Udaipur, India. *Biological Forum*, Biological Forum- An International Journal, 1(2), pp 97-102.
- Shannon C.E. and Wiener W. (1963). *The Mathematical Theory of Communication*, Univ. Illinois Press, Urbana. Pp. 125.
- Unanam, A.E. and Akpan, A.W.(2006). Analysis of physicochemical characteristics of some freshwater bodies in Essien Udim Local Government area of Akwa Ibom State, Nigeria. In: Proceeding of the 21st Annual Conference of the Fisheries Society of Nigeria (FI50N) Calabar.
- United Nation Environmental Programme (2011). "Environmental Assessment of Ogoni land." Kenya: UNEP. Retrieved on 9th January, 2016 from http://postconflict.unep.ch/publications/OEA/UNE_P_OEA.pdf
- Wood D.R. (1975). *Hydrobotanical Method*. Baltimore, Maryland University Park Press, pp. 173.

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An Ecological Survey Of Benthic Macroinvertebrates Of Sombreiro River At Agba-Ndele, Rivers State

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Abstract

The study was an ecological survey of the benthic community along the freshwater axis of the Sombreiro River at Agba-Ndele for a period of 6 months from September 2017 – February 2018. Sediment sample were taken with the help of Eckman grab on a monthly basis from five stations and analyzed for macro-benthic invertebrates. A total of 581 individuals from fifteen species belonging to 12 families, five classes and three phyla of macro-benthic invertebrates were recorded from study area. In terms of class abundance, Insecta dominated the benthic community with 59.50% (335 individuals), followed by Oligochaeta 17.58% (99 individuals). Gastropoda 7.10% (40 individuals) and Malacostraca which had the least of 1.78% (10 individuals) of the total macrofauna of the study. Three indices; Shannon-Weiner Index, Simpson's dominance and Margalef index were used to calculate the diversity index which showed low values of 0.17, 0.23, 0.23, 0.33, 0.35 and 0.27 across the months. The weak diversity indices suggest unfavourable aquatic condition of the study area. Various management strategies such as periodic limnological measures should be carried out on the river to monitor and track the trend of the biodiversity and water quality. Educating the residents along Sombreiro river on the implications of improper waste disposal on the river biodiversity was imminent.

Keywords: Mudflat, bottom dwellers, bioaccumulation, indicator species

Introduction

Macro-benthic invertebrates are bottom dwelling organisms that can be seen (Olamide, 2017). The aquatic environment is home to different phyla such as annelida, mollusca, arthropoda, coelentrata and chordata where their major function is in the distribution and circulation of nutrients in the aquatic ecosystem. They form the link between the available nutrients in detritus and useful protein in fish (Ezekiel *et al*, 2011). The abundance of benthic invertebrates depends on physical and chemical properties of the bottom of a water column. The presence or absence of a benthic species in a particular environment can be used as a bio-indicator of a specific environment and habitat conditions (Sharma *et al.*, 2000). Macro-benthic invertebrates are often used for sediment quality assessment both in freshwater and marine environments; their abundance and diversity depict the changing environmental conditions. The presence or absence of macro-benthic invertebrates has been used as a good indicator of both periodic and persistent impact of anthropogenic influences on river conditions and other aquatic environments (Olamide, 2017). Invariably, alteration in the macro-benthic community is used as an indicator of the state of the aquatic system (Armitage *et al.*, 1983).

The distribution of aquatic organisms is the result of interactions among their ecological roles, the physical conditions that characterized the habitats, and food availability. Thus, the community structure of macro-benthic invertebrates depend on several factors, namely water quality, type of substratum, particle size of sediment, water flow, organic matter availability and oxygen concentration (Cummins, 1995).

The abundance and richness of our aquatic ecosystems are changing as a result of harvesting, habitat destruction, pollution, exotic invasion and climate change (Charvet *et al.*, 1998). Increase in fishing activities, washing, bathing and other anthropogenic activities is on the increase and could lead to a change in the physico-chemical characteristics and biota of the river. Increase in water pollution is more compared to the terrestrial; this is as a result of the release or dumping of poisonous materials of all types into the aquatic environment. When pollutants enter the water bodies, they change water qualities, bind the sediment and accumulate in aquatic biota causing anemia, disturbances of physiological functions and mortalities of fish and other aquatic organisms. Owing to these changes in physico-chemistry in Sombreiro River, there had not been any study in recent time to examine the impact of these variabilities on the benthic macro invertebrates' composition of the river. Hence, this research sought to bridge the gap. The objective of the study was to examine the species composition, diversity and abundance of benthic macro invertebrates of the Sombreiro River, and to determine monthly variation of the benthic macroinvertebrates' abundance.

Materials And Methods

Study Area

The study was conducted in the Sombreiro River at of Agba-Ndele, Rivers State in the lower Niger Delta. They share a geographical boundary with Rumuewhor by the North, Rumuekepe by the south and AbuaOduval by the East. The Niger Delta basin covers all the land between latitude 4 41' N and 5 35'N and longitude 5 26'E and 7 37'E (Power *et. al*,1985).

Collection of Benthic Samples

At each station, replicate samples were taken with the help of Ekman grab measuring 225m³. When the grab touches the bottom, the trigger is pulled using a messenger and the grab closes, collecting the sample. Each sample was transferred into sample buckets and labelled according to the stations. The samples were preserved in 10% formalin and stained with eosin to ease sorting in the laboratory. The retained specimens were kept in labelled plastic containers for further laboratory analysis.

Macrobenthic Invertebrates

Macrobenthic invertebrates were sorted out by transferring them into a plastic tray. Moderate volume of water was added to improve visibility. Large benthic organisms were picked with forceps while smaller ones were pipetted out. All the macrobenthic invertebrates that were sorted were then preserved in 10% formalin for further identification and counting. Benthic macro invertebrates were identified under dissecting microscope and identification was done using the keys provided in Day (1967).

Shannon Weiner index for measuring biological diversity was used to measure diversity of macrobenthic invertebrate in Sombreiro River (Maiti, 2004).

Density = Total number of animals / Area of sample unit Shannon-Wiener index and Margalef index were used to calculate diversity and Pielou's index (J) of evenness was also applied to compute relative density.

$$H = -\sum P_i \log_2 P_i$$

$$H = \left(\frac{n_i}{n}\right) \log_2 \left(\frac{n_i}{n}\right) \text{ (Shannon-Wiener, 1963).}$$

$$P = \frac{n_i}{n}$$

P_i = Proportion of the Community belonging to the ith species

ST = The total number of species

$$D = S-1 / \ln N \text{ (Margalef, 1967)}$$

Where;

D= Diversity

S= The number of species collected

N= The total number of individuals

$$J = H/H_{\max} \text{ (Pielon, 1969)}$$

Where;

H = diversity index (Shannon- Wiener)

$$H_{\max} = \log 2S$$

Data Analysis

Paleontological Statistics Software Package (PAST) V.2.17c (2013) was used to estimate the species diversity and evenness in each station of the river using Shannon - Wiener diversity index.

RESULTS

A Total of 15 species belonging to 12 families and three phyla namely; Annelida, Mollusca, and Arthropoda were identified from the study locations. The phylum Arthropoda had 8 species while the Phylum Annelida had 4 species and the least was 3 species from the Phylum Mollusca.

Chironomus larvae had the highest abundance of 310 with a mean density of 62.0 m³, followed by *Libyodrilus* sp which had 67 with a mean density of 13.4m³, *Hirudomedicinalis* had 63 with a mean density of 12.6m³. *Africanogyrus* sp and *Amphizoasphad* 6 and a mean density of 1.2 m³ while *Culex* sp had the lowest of 1 with a mean density of 0.2m³.

The result of monthly collections of benthic macroinvertebrates in Sombreiro river from the month of September 2017 to February 2018 showed the highest number of species (166) recorded in the month of September, followed by November (108), then February had 112, October had 67, December and January had the least value of 64 each (Table 1).

The percentage composition of families and species in each class of benthic invertebrates is presented in Table 2. A total of 11 families with 15 species from 5 classes was presented. Insecta had the highest number of 4 families with 5 species (33.3 %), followed by Malacostraca with 3 families and 3 species, Gastropoda had 2 families with 3 species (20.0%) respectively. Oligochaeta had 2 families and 2 species, Hirudinea had 1 family and 2 species of (13.3%) respectively. The percentage abundance of each class of benthic organisms as observed in this investigation from September 2017 to February 2018 respectively is shown in Table 2. In terms of class abundance, Insecta dominated the benthic community with 59.50% (335 individuals), followed by Oligochaeta 17.58% (99 individuals). Gastropoda which accounted for 7.10% (40 individuals) while Malacostraca had the least of 1.78% (10 individuals).

Table 1: Benthic Macroinvertebrates Collection in Sombreiro River Agba-Ndele from September 2017 to February 2018.

SPECIES	Month						Total
	Sept	Oct	Nov	Dec	Jan	Feb	
<i>Libyodrilussp</i>	30	10	10	8	4	5	67
<i>Allonaissp</i>	0	2	0	10	10	10	32
<i>Hirudomedicinalis</i>	20	5	10	7	9	12	63
<i>Limnoblendasp</i>	3	0	0	7	9	12	31
<i>Lymneanatalensis</i>	0	0	10	0	0	20	30
<i>Africanogyrussp</i>	6	0	0	0	0	0	6
<i>Bulinusforskalii</i>	2	0	0	1	0	1	4
<i>Chironomus larvae</i>	100	50	70	30	20	40	310
<i>Culex sp</i>	0	0	0	0	0	1	1
<i>Anopheles sp</i>	5	0	6	0	0	2	13
<i>Ranatrasp</i>	0	0	1	0	4	0	5
<i>Amphizoasp</i>	0	0	0	1	0	5	6
<i>Desmocaristrispinosa</i>	0	0	0	0	3	0	3
<i>Caridinasp</i>	0	0	0	0	2	0	2
<i>Gammarus sp</i>	0	0	1	0	3	4	8
TOTAL	166	67	108	64	64	112	581

Table 2: Percentage Abundance Of Each Class Of Individuals Benthic Organism

Taxonomic group	Total no. of individual	Mean no. of individual	Percentage composition
Oligochaeta	99	49.5	17.58
Hirudinae	79	39.5	14.03
Gastropoda	40	20	7.10
Insecta	335	167.5	59.50
Malacostraca	10	5.0	1.78
Total	563	281.5	99.99

The result of the Shannon – wiener species diversity across the stations had the highest value in station 2 (0.55), followed by station 3 and 5 (0.27) respectively. Station 4 had (0.17) and the least was recorded in station 1 (0.2) Evenness had the highest value in station 2 (0.79), followed by station 3 and 5 (0.39) respectively. Station 1 (0.29) and the least was recorded in station 4(0.25). Margalef's index had the highest value in station 2 (2.17), followed by

station 1 (2.01). Station 3 had (1.91) and the least was recorded in station 5 (0.99). Simpson's Dominance had the highest value in station 4 (0.92), followed by station 1 (0.91) then station 3 and 5 (0.85) respectively. The least was recorded in station 2 (0.62).

The result of the monthly species diversity from the month of September 2017 to February 2018 is presented in Table 3. Shannon-wiener had the highest value in the month of January (0.36), followed by the month of December (0.33). October and November had (0.23) respectively. September had (0.17) and the least was recorded in the month of February (0.3). Evenness had highest value in the month of January (0.52), followed by December (0.48), February had (0.43), October and November had (0.33) respectively while the least was recorded in the month of September (0.25). Margalef's index had the highest value in the month of September (0.91), followed by October (0.89), November had (0.88), December had (0.82), February (0.83) and the least was recorded in the month of January (0.78).

Table 3: Monthly Species Diversity From September 2017 To February 2018

VARIABLES	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.
No. of Species	7	4	7	7	8	10
No. of Individuals	166	67	108	64	64	112
H	0.17	0.23	0.23	0.33	0.35	0.27
E	0.25	0.33	0.33	0.48	0.5	0.39
M	1.17	0.71	1.28	1.44	1.73	1.95
D	0.91	0.89	0.88	0.82	0.78	0.83

H – Shannon Wiener Diversity Index; E – Evenness; M – Margalef Index; D – Simpsons' Dominance

DISCUSSION

Fifteen species was represented by 12 families, five classes and three phyla of macrobenthic-invertebrates were identified. Insecta had the highest number of four families with five species (33.3 %), followed by Malacostraca with three families and three species, Gastropoda had two families with three species (20.0%) respectively. Oligochaeta had two families and two species, Hirudinea had one family and two species of (13.3%) respectively. The low diversity of the macro benthic invertebrate fauna represented in this study is not different from other studies that have been carried out in the Niger Delta. Woke (2004) reported a total of 14 taxa of benthic macroinvertebrates belonging to 12 families and five classes from Nta-Wogba stream, Port Harcourt. Ezekiel *et al.*, (2011) reported 28 species belonging to 14 families, six classes and three phyla from the Sombreiro River, Umeozor (1995) also recorded 23 groups from New Calabar River; Hart and Zabbey (2005) reported 30 groups belonging to 20 families and five classes and Ansa (2005) recorded 28 families six classes and five phyla. These similarities could be caused by closeness in their locations, time, food availability and factors that influence the physical and chemical characteristics of the water bodies. Organisms need adequate food for their survival and growth (Ibemenuga and Inyang, 2006).

The benthic macro invertebrate composition result of this study is also similar to the results of other studies from other water bodies in Nigeria. Olamide (2017) recorded five families with a total of 128 macrobenthic invertebrates belonging to five species in Owena reservoir. Andemet *et al.*, (2012) recorded 10 genera belonging to three phyla from a total of 513 individuals at Ona River. John *et al.*, (2013) have also recorded low distribution from the Agbede flood plain. The differences that occur in species distribution could be caused by ecological differences in their environment and period of investigation of the water quality. Immediate substrate for occupation and food availability may also affect the distribution of the macro-invertebrate communities (Dance and Hynes, 1980).

The dominance of *Chironomus* larvae in this work corresponds with the report of Andemet *et al* (2012); Woke and Umesi, (2018) and Abed-Nego *et al.*, (2016). The dominance of *Chironomus* larvae in the Sombreiro River (Agba-

Ndele) may be based on the ability of insects to thrive in polluted environments probably due to the presence of haemoglobin a pigment that transports and stores dissolved oxygen (Tyokumbeet *et al.*, (2002). The diversity of benthic macroinvertebrates in this work showed that Margalef, Shannon–Wiener, Evenness and Simpson's Dominance indexes in the stations were generally low and this compared favorably with the result of Ezekiel *et al.*, (2011) who reported low values for Margalef's species richness and Shannon-Wiener diversity Index.

Conclusion

Macrobenthic invertebrates are bottom dwellers and can be seen without the aid of a microscope. Species collected were from three phyla Annelida, Mollusca, and Arthropoda. The phylum Arthropoda had 8 species while the phylum Annelida had 4 species and the least was 3 species from the phylum Mollusca. A Total of 581 individuals accounting for 15 species belonging to 12 families were identified from the study locations.

Macrobenthic invertebrates are often used for accessing the sediment. The abundance and diversity of the benthic organisms show the environmental condition and it depends mainly on the physical and chemical properties of the water and sediment. Different groups of macro invertebrates have different tolerances to pollution, which means they can serve as useful indicators of water quality. The presence or absence of a benthic species is used as an indicator of that habitat. The dominant macro benthic invertebrate fauna of the river recorded were pollution tolerant species. The low number of benthic macro invertebrate of the river and the dominant species (*Chironomus* larvae and *Allonaia* species) being pollution tolerant suggest that the river is under stress. The river is relatively polluted with anthropogenic activities from within the community and other surrounding communities especially the waterfront dwellers who release raw human excreta, detergent, oil spill and wastewater from the communities.

References

- Abed-Nego O., Aiwerioghene, Adeolapo A.A. (2016)): Evaluation of some Physico-Chemical Parameters and Benthic Macro invertebrates of Ikere Gorge Reservoir in Oyo State, Nigeria. *Journal of Applied Sciences and environmental Management*. 20(4): 1097-1103
- Andem, A. B., Okorafor, K. A., Udofia, U., Okete, J. A. & Ugwumba, A.A.A (2012). Composition, Distribution and Diversity of Benthic Macroinvertebrates of Ona River, South-west, Nigeria. *European Journal of Zoological Research*, 1(2):47-53.
- Ansa, E.J., 2005. Studies of the benthic macrofauna of the Andoni flats in the Niger Delta Area of Nigeria. Ph.D Thesis, University of Port Harcourt, Port Harcourt, Nigeria, pp: 242.
- Armitage P.D., Moss D., Wright J.F, and Furse M.T. (1983) The performance of a new biological water quality score system based on macro-invertebrates over a wide range of unpolluted running water sites. *Water Research*, 17: 333-347.
- Charvet, S., Kosmala, A. and Statzner, B. (1998). Biomonitoring through biological traits of macrobenthic invertebrates. *Archive fur Hydrobiologie*, 142 (4): 415-432.
- Cummins, K. W. (1995). Structure and function of stream ecosystems. *Biological Science* 24 (11):631-641.
- Dance, K. W. and Hynes, H. R. N. (1980). Some effects of agricultural land use on stream insect communities. *Environmental Pollution*, 22 (Series A), 14 – 28.
- Day, J.A., (1967). A monograph on the Polychaeta of Southern Africa Part I Errantia. British Museum of Natural History, London. pp: 458.
- Ezekiel, E. N., Hart, A. I. and Abowei, J. F. N. (2011). The Distribution and Seasonality of Benthic Macro-Invertebrates in Sombreiro River, Niger Delta, Nigeria. *Research Journal of Applied Science, Engineering and Technology* 3(4): 264-271, 2011 ISSN : 2040-7467.
- Hart, A. I and Zabbey, (2005). Physico-chemical and benthic fauna of Woji creek in the lower Niger Delta, Nigeria. *Environment. Ecology*, 23(2):361-368.
- Ibemenuga, K. N. and Inyang, N. (2006). Macroinvertebrate Fauna of a Tropical Freshwater Stream in Nigeria. *Animal Research International* 3(3): 553 – 561.
- John B.A., Jalal K. C. A and Kamaruzzaman B.Y. (2013): Macrobenthic Diversity in Horseshoe Crab Nesting Ground-Balok Station, Pahang, Malaysia. *Oriental Journal of Chemistry* 29 (4) :1311-1318.
- Maiti, S. K. (2004). Handbook of Methods in Environmental Studies: Water and Wastewater Analysis. Second Edition ABD Publishers B-46, Natraj Nagar, Imliwala Phatak Jaipur, India. Vol. 1 Pp. 225-258.
- Margalef, R. (1967): Diversity and Stability: A Practical Proposal and a Model of Interdependence. *Brookhaven Symposia in Biology*. 20: 25 -37
- Olamide, O.O. (2017). Composition and Abundance of macro-benthic invertebrates in Owena reservoir, Ondo State, Nigeria. *International Journal of Aquatic Science*, 8 (2): 83-98.

- Pielou, E.C. (1969). An Introduction to Mathematical Ecology. Wiley Interscience. John Wiley and Sons, New York.
- Power M.E, Mathews W.J, Stewart A.J. (1985) Grazing minnows, piscivorous bass and stream algae: dynamics of a strong interaction. *Ecology* 66: 1448-1456ff
- Shannon C.E. and Wiener W., (1963). The Mathematical theory of communication. University of JuionisPress,Urbana. 117.
- Sharma, H. B., Agrawal, P. K. and Senagupta, P. (2000). Water quality of sewage drains entering Yamuna River at Mathura (UP). *Journal of Environmental Biology*, 21(4):375-378.
- Tyokumbur, E.T., T.G. Okorie and O.A. Ugwumba, (2002).Limnological assessment of the effects of effluents on macroinvertebrates fauna in Awba stream and Reservoir, Ibadan, Nigeria, *The Zoologist*, 1(2): 59-69.
- Umeozor, O.C., (1995). Benthic fauna of New Calabar River, Nigeria. *Tropical Freshwater Biology*, 4: 41-51.
- Woke G. N and Umesi N., (2018): Comperative Study of Sediments Samples from Brackish and Freshwater in the Lower River Niger Delta, Nigeria.*International Journal of Research in Agriculture and Forestry*, 5 (5): 1-7.
- Woke, G.N. (2004). An Ecological Survey of Benthic Macro Invertebrates of the Nta – wogba Stream, Port Harcourt. M.Sc. Thesis in Animal and Environmental Biology department, Faculty of Science, University of Port Harcourt, Rivers State, Nigeria.

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Physico-Chemical Characteristics Of Elele Alumini Stream, PorHarcourt, Nigeria.

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Abstract

The physico-chemical characteristics of Elele Alumini stream was studied between April to June, 2018. The water samples collected from the 3 stations were analyzed in the laboratory following standard method of APHA. The result of the physico-chemical parameters studied showed that the mean values for temperature, DO and chlorophyll 'a' (in mg/l) were respectively, 29.50 ± 0.67 , 6.60 ± 0.46 and 2.01 ± 0.13 while pH was 5.87 ± 0.29 . Only phosphate and nitrate showed significant relationship spatially at probability level of $P \leq 0.05$. The physico-chemical variables were all within the permissible limits recommended by WHO and FEPA. The stream is therefore not stressed but suitable for the survival and growth of aquatic life. Therefore adequate measures should be taken to ensure that anthropogenic activities in the area are monitored to avoid discharge of harmful wastes into the Stream capable of causing havoc to aquatic life including man.

Key words: Physico-chemical parameters, Elele-Alumini Stream, Port Harcourt.

Introduction

The physico-chemical parameters of an aquatic ecosystem are very important in assessing the composition of any aquatic biota and also they are sensitive to pollution (Taylor *et al*, 2000). Physicochemical variables helps in assessing the functionality of a lake ecosystem on the basis of its productivity, nutrient balance and resource cycling which is essential in estimating ecological carrying capacity of the system and indicates the sources and amount of pollutants in the form of nutrients and solids (Kalyani and Kushwah., 2015). Anthropogenic influences affect physicochemical parameters of water and are said to be known sources of water pollution which could be urban, industrial and agricultural activities (Irfan and Shakil, 2012). Arimoro and Oganah (2010), conducted a research study at Orogo River, Southern Nigeria and opined that zooplankton distribution and abundance were affected by some physicochemical parameters or local environmental conditions such as temperature, depth, dissolved oxygen, alkalinity and conductivity which were said to account for 68% of variation in zooplanktons.

The trophic status and water quality criteria, parts of limnological study reveal the successional stage and point and non-point sources of pollution (Arlinghaus, Johnson and Wolter, 2008). As the natural and anthropogenic causes are identified, comprehensive conservation strategies could be chalked out to sustain the use of a lake ecosystem.

Chlorophyll 'a' concentrations are an indicator of phytoplankton abundance and biomass in coastal and estuarine waters, effective measures of trophic status, potential indicator of maximum photosynthetic rate and are a commonly used measure of water quality (Nelson, Demaster, Dunber, and Smith, 1996).

This research therefore became necessary since there is growing number of anthropogenic activities around the Elele Alumini Stream and considering the fact that the Stream is a major source of water for the inhabitants of the area. This study therefore intended to assess the variability in some physicochemical variables of this Stream.

Materials and Methods

Study area

The stream is located at Elele Alimini in Emohua local government area of Rivers state, Nigeria which lies between longitudes $5^{\circ} 3'0''$ North, and latitudes $6^{\circ} 44'0''$ East. It shares boundary with the local government areas such as Ahoada, Ikwere and Obio/Akpo. 65% of the people in the area are engaged in primary activities such as: farming and fishing. The stream is known to take empty its course into the New Calabar River.

Sampling Stations

Three sampling locations were purposely established which were at least 500m apart through a reconnaissance survey from the upstream to through the midstream to the downstream which include Minikwu (Station 1), Miniezi (Station 2) and Miniegebele (Station 3).

Sampling Collection and Analysis

The water samples for physico-chemical analysis were collected once a month for three(3) months between April and June from the three stations. All the kegs containers were kept in ice - chest box and transported to the laboratory for further analysis. Dissolved oxygen (DO), Conductivity, temperature and pH were measured in-situ using Water Quality Checker (Horiba U-10) while other parameters including chlorophyll 'a' were determined following the Standard method recommended by APHA (1998).

Statistical Analysis

One-way Analysis of Variance (ANOVA) was used to test for statistical difference in the means of the water parameters. The results were also computed statistically using software package for Windows, version 17 at 1% and 5% confidence levels ($P \leq 0.05$). Pearson correlation test was also carried out to demonstrate correlation between the physicochemical parameters.

Results and Discussion

Temperature ranged between 28.4°C and 30.5°C with the overall mean of $29.50 \pm 0.67^\circ\text{C}$. Temperature showed no significant variation spatially and temporarily (Table 1& 2). This temperature range is within the range (26-30°C) obtained by Deekae (2009) in Luubara creek, Niger Delta. The slight variation in Station and Month in this study could be attributed to climatic changes, degree of exposure to sunlight and surrounding vegetation (NEDEECO, 1961). pH ranged between 5.4 and 6.4 with the overall mean of 5.87 which showed acidic condition conducive for aquatic life. Dissolved oxygen with the mean value of 6.60 ± 0.46 mg/l in this study is within the permissible limit recommended by WHO. The mean values of nutrients (PO_4 , NO_3 and SO_4) observed in this study are all within the permissible limits that permit productivity in the aquatic ecosystem. Only phosphate and nitrate showed significant relationship spatially at probability level of $P \leq 0.05$. The mean value of chlorophyll 'a' (2.01 ± 0.13 mg/l) showed that the Stream is productive which is in line with the assertion that chlorophyll 'a' is an effective measure of trophic status, potential indicator of maximum photosynthetic rate and are common used for measure of water quality (Nelson, et al., 1996). The result showed strong, significant and positive correlation between pH and temperature (Table 3).

Table 4.2: Spatial Mean Value of Physico-Chemical Parameters of Elele Alumini Stream

Parameters	Station 1	Station 2	Station 3	Overall Mean
Temperature ($^\circ\text{C}$)	29.30 ± 0.62^a	29.53 ± 0.25^a	$29.66 \pm 1.11a$	29.50 ± 0.67
pH	6.06 ± 0.30^a	$5.90 \pm 0.00a$	$5.63 \pm 0.32a$	5.87 ± 0.29
Salinity ($^\circ/00$)	0.06 ± 0.02^a	0.05 ± 0.01^a	0.03 ± 0.01^a	0.04 ± 0.02
Conductivity ($\mu\text{S}/\text{m}$)	130.16 ± 26.36^a	123.70 ± 14.95^a	129.86 ± 20.25^a	127.91 ± 18.49
Alkalinity (mg/l)	46.93 ± 0.97^b	51.93 ± 2.66^a	54.40 ± 3.41^a	51.08 ± 3.97
Dissolve Oxygen (mg/l)	$6.50 \pm 0.62a$	$6.56 \pm 0.05a$	6.73 ± 0.64^a	6.60 ± 0.46
BOD (mg/l)	2.01 ± 0.07^a	2.35 ± 0.25^a	$1.93 \pm 0.41a$	2.10 ± 0.31
Phosphate (mg/l)	0.08 ± 0.00^a	0.07 ± 0.02^a	0.06 ± 0.00^a	0.04 ± 0.01
Nitrate (mg/l)	0.50 ± 0.10^a	0.52 ± 0.07^a	0.20 ± 0.10^b	0.40 ± 0.17
Sulphate (mg/l)	$1.83 \pm 0.28a$	$1.47 \pm 0.23b$	$1.43 \pm 0.15b$	1.57 ± 0.27
Chlorophyll "a" (mg/l)	$2.00 \pm 0.10a$	$2.00 \pm 0.20a$	$2.03 \pm 0.15a$	2.01 ± 0.13

Means with the same superscript in the same column are not significantly different

Table 4.1 Table 4.2: Monthly Means Value Of Physico-Chemical Parameters

Parameters	April	May	June	Overall Mean
Temperature ($^{\circ}\text{C}$)	29.53 $\pm$ 0.95a	29.63 $\pm$ 0.42a	29.33 $\pm$ 0.81a	29.50 $\pm$ 0.67
pH	5.90 $\pm$ 0.50a	5.80 $\pm$ 0.26a	5.90 $\pm$ 0.10a	5.87 $\pm$ 0.29
Salinity ($^{\circ}/_{\text{00}}$)	0.06 $\pm$ 0.20a	0.04 $\pm$ 0.02a	0.04 $\pm$ 0.00a	0.04 $\pm$ 0.02
Conductivity ($\mu\text{S}/\text{m}$)	120.40 $\pm$ 9.75b	136.50 $\pm$ 25.43a	126.83 $\pm$ 20.73b	127.91 $\pm$ 18.49
Alkalinity (mg/l)	49.30 $\pm$ 2.78a	52.33 $\pm$ 3.78a	51.63 $\pm$ 5.78a	51.08 $\pm$ 3.97
Dissolve Oxygen (mg/l)	6.43 $\pm$ 0.37a	6.90 $\pm$ 0.36a	6.46 $\pm$ 0.61a	6.60 $\pm$ 0.46
BOD (mg/l)	2.16 $\pm$ 0.01a	1.88 $\pm$ 0.25a	2.26 $\pm$ 0.23a	2.10 $\pm$ 0.31
Phosphate (mg/l)	0.06 $\pm$ 0.01a	0.07 $\pm$ 0.01a	0.07 $\pm$ 0.01a	0.04 $\pm$ 0.01
Nitrate (mg/l)	0.33 $\pm$ 0.20b	0.46 $\pm$ 0.15a	0.41 $\pm$ 0.20a	0.40 $\pm$ 0.17
Sulphate (mg/l)	1.33 $\pm$ 0.15a	1.66 $\pm$ 0.30a	1.73 $\pm$ 0.23a	1.57 $\pm$.27
Chlorophyll "a" (mg/l)	1.90 $\pm$ 0.10a	2.10 $\pm$ 0.10a	2.03 $\pm$ 0.15a	2.01 $\pm$ 0.13

Means with the same superscript in the same column are not significantly different ($P>0.05$).

Table 3. Correlation Coefficient of Physico-chemical Characteristics of Elele Alumini Stream

	temp	pH	salinity	condu	Alkal	DO	BOD	PO4	NO3	SO4	Chl"a"
Temp	1.00										
pH	0.85**	1.00									
	0.002										
Salinity	-0.048	0.775**	1.00								
	0.092	0.007									
Conduct	-0.368	0.227	0.142	1.00							
	0.165	0.279	0.358								
Alkalinity	-0.170	-0.312	-0.517	0.303	1.00						
	0.331	0.207	0.077	0.214							
DO	-0.400	0.251	-0.094	0.318	0.398	1.00					
	0.143	0.257	0.405	0.202	0.144						
BOD	-0.512	0.510	0.575	0.027	0.097	0.017	1.00				
	0.079	0.080	0.053	0.472	0.402	0.483					
Phosphate	-0.372	0.450	0.247	0.280	-	-0.271	-	1.00			
	0.162	0.112	0.261	0.233	0.258	0.240	0.110				
					0.251		0.390				
Nitrate	-0.112	0.398	0.356	-	-	-0.156	0.249	0.629*	1.00		
	0.387	0.144	0.173	0.128	0.399	0.344	0.259	0.035			
				0.372	0.144						
Sulphate	-0.141	0.268	-0.005	0.399	-	-0.108	-	0.708*	0.495	1.00	
	0.359	0.243	0.495	0.144	0.330	0.392	0.155	0.016	0.080		
					0.193		0.345				
Chloro"a"	0.068	-0.021	-0.402	0.152	0.143	0.596*	-	-0.156		0.239	1.00
	0.431	0.479	0.142	0.348	0.357	0.045	0.334	0.344	0.44	0.268	
							0.190		0.056		

** Correlation is significant at 0.01.*Correlation is significant at 0.05

CONCLUSION AND RECOMMENDATION

Physico-chemical characteristics of Elele Alumini stream shows that the water is not stressed but rich and therefore conducive for the survival and growth of aquatic organisms. Therefore adequate measures should be taken to ensure that anthropogenic activities in the area are monitored to avoid discharge of harmful wastes into the stream capable of causing havoc to aquatic life including man.

References

- APHA.(1998).*Standard methods for the examination of water and waste water*.20th (Ed), Washington D.C1213pp.
- Arimoro, F.O and A. O. Oganah (2010). Zooplankton Community Responses in a Perturbed Tropical Stream in the Niger Delta, Nigeria.*The Open Environmental & Biological Monitoring Journal*, 2010, 3, 1-11.
- Arlinghaus, R., Johnson, B.M., and Wolter, C. 2008. The past, present and future role of limnology in freshwater fisheries science. *International Review of Hydrobiology*, 93:541–549.
- Deekae, S.N. (2009). Population biology of the freshwater shrimps (*Macrobrachium Macrobrachion*) in Luubara Creek, Rivers state. Ph.D Thesis (unpublished), Dept of Fisheries, and Aquatic Environment, Rivers State University, Port Harcourt.
- Irfan R, Shakil AR (2012). Impact of anthropogenic activities on water Quality of Lidder River in Kashmir Himalayas. *Environ Monitoring Assessment*; 185(6).
- NEDECO (1961). The waters of the Niger Delta. Report of an investigation by NEDECO (Netherlands Engineering Consultants). The Hague, pp 210 – 228.
- Nelson, D.M., Demaster, D.J. Dunbar, R.B & W.O. Smith, Jr. (1996). Cycling of organic and Biogenic Silica in the Southern Ocean. Estimates of water column and sedimentary Fluxes on the Ross sea continental shelf. *Journal of Geophysical Research*, 101, 18,519-18,532.
- Taylor, S.E, L.C. Klein, Brian P. Lewis, T. L. G. Regan A. R. G. Gurung, and John A. U. (2000). Biobehavioral Responses to Stress in Females: Tend-and-Befriend, Not Fight-or-Flight. *Psychological Review* 107, 3, 411-429

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Comparative Evaluation of Heavy Metal Accumulation in Bodo Creek, Niger Delta, Nigeria

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Abstract

The concentrations of some heavy metals in Bodo creek were evaluated between April and June 2019 from three sampling points (Stations 1, 2 and 3). Water samples collected were analysed for heavy metals using Atomic Absorption Spectrophotometer (Solaar-Thermo-71906). The results showed that the mean concentrations (mg/L) of Cr (0.367±0.10), Ni (0.270±0.102), Pb (0.202±0.043) and Cd (0.095±0.019) in order of magnitude was Cr > Ni > Pb > Cd with station 2 having the highest concentration among all heavy metals studied and Cr having the highest concentration across the months. ANOVA results showed that there was significant difference across the stations at P<0.05. The concentration of all the heavy metals exceeded the standard permissible limits (WHO, USEPA, EPA and SON) of drinking water and survival of aquatic life by affecting their protein and glycogen reserves. Failure to control the exposure will result in severe complications in the future because of the adverse effects caused by heavy metals. It was recommended that remedial measures should be put in place to ensure safety of life and properties of the inhabitants of the area.

Key words: Heavy metals, Accumulation, Bodo creek, Niger Delta, Nigeria

Introduction

The mutilation of water quality as a result of discharge of pollutants into the aquatic ecosystem is a constraint faced by most industrial cities globally. The uncontrolled discharge of waste effluents into water bodies have negatively impaired both water quality and aquatic life (Abidaet *et al.*, 2008). Most of our water resources are gradually becoming polluted due to the addition of foreign materials of organic origin from the surroundings where industrial and municipal effluents are discharged (Abidaet *et al.*, 2008). Rapid urbanization and industrialization with improper environmental planning often lead to discharge of industrial and sewage effluents into lakes. Most water bodies such as lakes and creeks have a complex and fragile ecosystem, as they do not have a self-cleaning ability and therefore readily accumulate pollutants (Abidaet *et al.*, 2008).

The high toxic and persistent nature of heavy metals in the environment has made heavy metals priority pollutants. For good environmental management an understanding of the changing concentration and distribution of heavy metals and their compounds in various compartments of the environment is of the essence.

The lack of natural elimination processes for metals aggravates severe situation. As a result, metals shift from one compartment within the aquatic environment to another including the biota often with detrimental effects, through sufficient bioaccumulation. Food chain transfer also increases the toxicological risk in humans (Rainbow, 1985; Mason, 1991). As a result of adsorption and accumulation, the concentration of metals in bottom sediments is expected to be higher than in the water above and this sometimes can cause secondary pollution problems. This is why bottom sediments are repository of heavy metals. Heavy metals are of considerable environmental concern due to their toxicity and cumulative behavior (Purves, 1985).

Pollution of aquatic environment caused by heavy metals is an important environmental problem, as heavy metals constitute some of the most dangerous toxicants that can bio-accumulate (Benson *et al.*, 2007). Metals that are deposited in the aquatic environment may accumulate in the food chain and cause ecological damage and therefore pose as threat to human health due to biomagnification overtime (Yilmaz & Yilmaz, 2004). Changes in oxidation state of the heavy metal can have profound effect on their toxicity and bioavailability (Donat & Briland, 1995). Discharges of inorganic and organic micro-pollutants from various industrial, agricultural and municipal sources have resulted in permanently contaminated water, sediments and the accumulation of chemicals in the aquatic food-chain.

Bodo creek serves as a strong livelihood support base for the people of Bodo and their neighbors (powellet *al* (1985). The creek provides ready incentives for capture fisheries, transportation cassava fermentation, fuel wood production, domestic waste disposal, small scale aqua-culture. The creek in the recent past had received quantum of discharges from domestic and industrial activities into it. This study is intended to enlighten individuals living around Bodo creek of increased level of heavy metals discharged by the amount of municipal and industrial waste effluents arising from domestic and industrial activities sited around the creek for remedial measures.

Materials and Methods

Sample Stations

The sampling stations in the Bodo creek were established at the upstream(Bon Sunday) middle stream (Bon Dorgbaa) and downstream (Bon Boopietoo) which are numbered as Stations 1-3 respectively .

Sample Collection Methods

Sample collections were carried out for a total duration of three months between April and June 2019. Water samples were collected in plastic containers previously washed and rinsed by appropriate reagent for the determination of concentration of heavy metals following standard method of APHA.

Laboratory Analysis of Heavy Metal Samples

The various heavy metals were determined using the Solaar Thermo-Elemental Atomic Absorption Spectrophotometer (AAS), Model-71906

RESULTS AND DISCUSSION

The study showed that the concentration of all the heavy metals studied in water exceeded the permissible limits stipulated for drinking water and aquatic life(WHO, 2008, WHO,2011, SON (2007), USEPA,2002 and EU,2010). The order of concentration of the heavy metals studied was Cr > Ni >Pb>Cd which is similar to that reported in many Niger Delta water bodies. Apart from Cd, the concentrations of all other heavy metals studied were significantly higher in station 2 than stations 1 and 3respectively which could be attributed to higher anthropogenic activities in the area or difference in other environmental factors. Chromium had the highest concentration among the heavy metals studiedwhich is confirmed by the assertion thatin aquatic environment, Cr is one of the biochemically active transition metals and that weathering of the earth crust is the primary and natural source of the chromium in the surface wateroccurring from time to time (Joseph, *et al.*,2012). Cadmium had the least concentration in this study among all the heavy metals studied and could be attributed to reduced agricultural activities and other natural source such as leaching which is confirmed by the assertion that apart from natural sources, other probable sources of this metal in surface water include leaching from Ni-Cd based batteries (Hutton *et al.*,1999), runoff from agricultural soils where phosphate fertilizers are used (Stoppler, 1991) and other metal wastes. The significant difference observed (ANOVA at P<0.05) in this study across the stations could be attributed to uniformity in anthropogenic activities in the respective stations.

Table 1. Overall Mean Values of Heavy Metals in the Study Area

Metal	Overall mean	Range	Permissible Limit			
			WHO	SON	EPA	USEPA
Pb	0.202 ±0.04	0.160- 0.27	0.01	0.01	0.02	0.07
Cd	0.095 ±0.02	0.071-0.120	0.003	0.003	0.005	0.002
Ni	0.270 ±0.10	0.187- 0.469	0.07	0.02	0.10	NS
Cr	0.367 ±0.11	0.260- 0.567	0.05	0.05	0.10	0.016

NS= Not Stated

Table 2. Spatial Mean Values of Heavy Metals in the Area

Metals/Station	1	2	3
Pb	0.169 ±0.02 ^b	0.257 ±0.01 ^a	0.179 ±0.01 ^b
Cd	0.081 ±0.00 ^a	0.116 ±0.01 ^a	0.089 ±0.02 ^a
Ni	0.211 ±0.00 ^b	0.399 ±0.06 ^a	0.201 ±0.01 ^b
Cr	0.341 ±0.01 ^b	0.493 ±0.07 ^a	0.267 ±0.01 ^b

Difference in superscript across the row shows significant difference

Table 3. Spatial Mean Values of Heavy Metals in the Area

Metals/Station	April	May	June
Pb	0.204 ±0.05	0.195 ±0.04	0.207 ±0.057
Cd	0.093 ±0.02	0.102 ±0.02	0.090 ±0.18
Ni	0.289 ±0.16	0.264 ±0.99	0.258 ±0.08
Cr	0.391 ±0.16	0.348 ±0.10	0.360 ±0.10

Conclusion and Recommendation

The results of this study showed that Bodo creek is polluted to the level that can stress the living organisms therein and can also be said to be unsafe for human consumption. The anthropogenic activities going on in and around the environment should be monitored or regulated to avoid indiscriminate discharge of waste into the creek. Monitoring the exposure and probable intervention for reducing additional exposure to heavy metals in the environment and in humans can become a major step towards prevention.

References

- Abida, B S. Harikrishna, K. Irfanulla, M. Ramaiah, K. Veena and K. Vinutha (2008), "Analysis of Flouride Level in Water and Fish Species of Sankey, Bellandur and Madi- vala Lakes of Bangalore. Rasayan," *Journal of Chemistry*, 1(3), 596-601.
- Benson, N.U., Essien, J.P., Williams, A.B. and D.E. Bassey (2007). Mercury Accumulation in Fishes from Tropical Aquatic Ecosystem in the Niger Delta, Nigeria. *Current Science*, 927: 81-785.
- EPA (Environmental Protection Agency), (2003). Drinking water quality standards. Edstrom Industries Waterford, Wisconsin 53185, 4230- MI4171, 1-12.
- European guideline for drinking water (EU, 2010). Drinking Water Inspectorate, Ergon House, Horseferry Rd, London, SW1P 2AL.
- Ezeonu E (2004). Chemistry in Nigeria: A national magazine of chemical society of Nigeria. 2: 17-20.
- Hutton, M., R. L. Chaney, C. R. Krishna, M. Murti, A. Olade and A. L. Page (1999), "Groups Report," In: T. C. Hutchinson and K. M. Meena, Eds., *Lead, Mercury, Cadmium and Arsenic in the Environment*, John Wiley, New York, pp. 35-41.
- Joseph, C. A, Mohammed, T. A., Zaynab, M. C, Fanna I. A. (2012). Assessment of Pollutants in Water and Sediment Samples in Lake Chad, Baga, North Eastern Nigeria. *Journal of Environmental Protection*, 3, 1428-1441
- Mason CF (1991). Biology of freshwater pollution. Prentice Hall, New York, USA: 387.
- Ndubuisi OL, Asia IO (2007) Environmental Pollution in Oil Producing Areas of the Niger Delta Basin, Nigeria: Empirical Assessment of Trends and People's Perception. *Environmental Research Journal* 1: 18-26.
- Powell, C.O, Deekae, S.N and Hart, A.1 (1985). Market survey of the periwinkle *Tympanotonus fuscatus* in Rivers State: Sizes, prices, trade routes and exploitation levels, 2(3).
- Purves D (1985). Trace-element contamination of the environment. Amsterdam, Netherlands. Elsevier: 243.
- Rainbow, P.S (1985). The biology of heavy metals in the sea. *International Journal of Environmental Studies* 25: 195- 211.
- SON (Standards Organisation of Nigeria), (2007). Nigerian standard for drinking water quality. *Nigerian Industrial Standard*, NIS 554, 1-30.
- Stoeppler, M (1991). Cadmium, In: E. Merian, Ed., *Metals and Their Compounds in the Environment: Occurrence, Analysis and Biological Relevance*, CCH, New York, 803- 851.
- USEPA (2002), "Risk Assessment: Technical Background Information," <http://www.epa.gov/reg3hwmd/risk>
- World Health Organisation (2008). Guidelines for drinking water quality (Electronic): Incorporating 1st and 2nd Addenda, 1(3).
- World Health Organisation (2011). Adverse Health effects of heavy metals in children: Children health and the environment, WHO Training package for the health sector.
- Yilmaz, A.B. and L. Yilmaz (2004). Influences of Sex and Seasons on Levels of Heavy Metals in Tissues of Greeniger Shrimp (*Penaeus semisulcatus* de Harur. 1844). *Food Chemistry*, 101: 1664-1669.

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