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CHALLENGES OF FISH PRODUCTION: THE
ROLES OF PUBLIC AND INDUSTRIAL
SECTORS



CONFERENCE PROCEEDINGS

37TH ANNUAL CONFERENCE FISHERIES SOCIETY OF NIGERIA

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EDITORIAL COMMENTS

All glory and adoration to Almighty God in the highest for the successful hosting of the 37th Annual Conference of our noble society tagged “Land of Beauty, 2022”. The conference was able to live up to its expectations as it attracted different people from different sectors (academia, students, artisans, industrialists, e.t.c) compared to the fear of the National Executive Council when we first won the hosting right regarding the security issues in the country. However, the attendance was not as much as that of previous conferences which was attributed to distance and fear of travelling by road for members; but yet we still had over 200 hundred in attendance (including students). This commendable achievement would not have been possible without Good leadership of our able and every dependable National Conference Coordinator, Professor Orire Abdullahi (Mfs) and the Assistance National Conference Coordinator, Dr. Abdulkarim Babangida (Mfs) coupled with the input and support of the Local Organizing Committee (LOC) led by Hon. Mohammed Inuwa Bassi. It is also important to appreciate the Executive members, FISON, Adamawa State Chapter led by Prof. O. A Sogbesan (*ffs*), Conference Coordinator, Prof. A.A. Kotos and all Conference Committees for their excellent and coordinated efforts for making the conference a memorable one. There is no conference without challenge but we thank God we were able to prepare and surmount all the challenges most especially the security challenge as there was no any security threats before, during and after the conference.

The keynote speaker, Prof. Anetehkai, A. Martin (FFs), Lead paper speaker, Dr. Abba, Y. Abdullahi (Ffs) and the Special paper presenter, Dr. Abdullahi, Yerima Yaji (Mfs) did justice to the aspect they were asked to make various contributions in line with the focus of this year conference- “National Insecurity and Challenges of Fish Production: the role of public and industrial sectors.”.

The technical sessions were very educative, informative and as well as interactive as it has always been in previous conferences. The heads and rapporteurs of each session were contacted ahead of time to notify them of their roles and responsibilities at the technical sessions. The presentation details such as date, time, duration, heads and rapporteurs were announced on the first day of the conference so that the authors can have all the necessary information for a possible hitched free presentation. There were 16 technical sessions presented in three days; 4 technical sessions immediately after the opening ceremony and 6 technical sessions on each of the next two days. The technical sessions were divided into ten thematic areas, namely: Aquaculture and Fish Nutrition, Fish Biology, Hydrobiology, Fish and Environmental Toxicology, Fish Breeding and Genetics, Fish Gear Technology, Fish Parasitology and Pathology, Fish Preservation, Processing and Marketing, Fisheries Economics, Insecurity, Gender issues, Climate change and Fisheries Governance. All technical sessions were objectively discussed and intellectually engaged in which questions, observations and comments that can improve the quality of the manuscripts were raised.

One hundred and sixty-two (162) manuscripts were received, processed and reviewed for the conference. One hundred and thirty-five manuscripts met the editorial guidelines and requirements for the conference submission. Nine manuscripts were not paid for by their authors, eight manuscripts failed to adhere to the editorial guidelines most especially the reviewer’s comments and observation while the remaining ten manuscripts were rejected because of poor quality.

I would like to express my profound gratitude to Dr. H. A. Adedeji (Mfs), Prof. L.U. Onyia (Mfs), Dr. Jegede, Oladele S. (Mfs) and Dr. Apollos Garba, (Mfs) for assisting in the editorial work as well as volunteered reviewers who sacrificed their leisure time to peer review the manuscripts. My appreciation is incomplete without recognizing the overwhelming supports of the immediate past and present President, Dr. L. A. Agbabiaka (*Ffs*) and Dr. Ansa Ebinmi (*Ffs*) towards the completion of the conference and the publication of the of the proceedings. I will like to sincerely appreciate the Fisheries Society of Nigeria (Adamawa Chapter) for the confidence bestowed on me. It is my pleasure to serve as the Conference Editor.

Prof. A.A. Kotos (Mfs)
(Conference Editor, Land of Beauty, 2022)

OPENING SPEECH

Speech of His Excellency, Rt. (Hon). Ahmadu Fintiri at the 37th Annual Conference of Fisheries Society of Nigeria, Yola Adamawa State

Greetings in the name of the Almighty God. I welcome you to the 37th Annual Conference of the Fisheries Society of Nigeria here in Adamawa.

This year anniversary is unique to have been first of its kind in the history of Adamawa state hosting all the fisheries stakeholders in the country. The choice of the state at the society 36th annual conference in Portharcourt was conveyed to me to have been keenly contested for by three states in which, Adamawa was the choice of all Nigerians present at the society Annual General meeting.

I wasn't surprised, knowing fully that the fame of the state in development and aquatic resources coupled with Adamawa been one of the riparian state to one of the two major rivers in Nigeria worth visiting.

The state is blessed with a lot of Fisheries resources, aquatic plants and other aquatic and amphibious animals. The beauty of our Njuwa festival which my government is engineering its resuscitation, creation of a ministry (Ministry of livestock and aquaculture development) that looks after our aquatic resources and releasing funds to the development of one of the biggest dams in the North east, called Kiri dam is of immense achievement to my administration.

The theme focusing on National Insecurity and Challenges of Fish Production: The roles of Private and Public Sectors is highly timing. Today, Adamawa has drastically come out of the norms and fears created by major insecurity act within the northeast. The support given to my administration by our security operatives and personnels coupled with our community cooperation had made this possible.

The state is blessed with River Benue and Gongola and some reservoirs such as Geriyo, Kiri, Njoboliyo, Ribadu, Wuroboki, Rugange, Njuwa to mention a few and a lot of freshwater fishes such as African mudcatfish, Tilapia, Carp, Upside down catfish, Lates, Bony Tongue fish, moonfish, to mention a few are housed in these water bodies.

The aquaculture development of the state has been so juicy and attractive to a lot of people in jobs creation and wealth development. My administration has also invested into developing the Luhu dam in Michika LGA and still developing more according to my Masterplan for the state.

The fisherfolks in the state; are about 600,000 household which their major livelihood depends on the water bodies. There are major fish markets in the state where fish from neighbouring countries are been transported to different parts of the country. The revenue generated from this livelihood cannot be underrated and for this and many other reasons, my administration will continue to give all maxima support to this important sector in agriculture.

The state government is always ready to partner with industrialists and organizations that are ready to invest into developing all these fisheries resources especially in value-addition not to fish alone but to the life of my people in Adamawa.

Ones again, I congratulate the Adamawa State Chapter of Fisheries Society of Nigeria for hosting this great conference and assure all the delegates from different state of enjoying their stay in the land of beauty.

Thank you and God bless

COMMUNIQUE OF THE 37TH ANNUAL CONFERENCE OF THE FISHERIES SOCIETY OF NIGERIA (FISON) HOSTED BY ADAMAWA STATE AT YOLA BETWEEN 30TH OCTOBER - 4TH NOVEMBER, 2022.

INTRODUCTION

The 37th Annual Conference of the Fisheries Society of Nigeria (FISON) was successfully hosted and held in Adamawa State at the Federal College of Education, Yola from 30th October to 4th November, 2022. The theme of the Annual Conference was “National Insecurity and Challenges of Fish Production: the Role of Public and Private Sectors.”.

OVERVIEW

The five-day conference had in attendance 250 participants from the Nigerian universities, research institutes, polytechnics, colleges of education, ministries and private sector operators as well as students of fisheries. The President of the Society, Dr. Agbabiaka Lukman Adegoke Ffs presided over the opening ceremony and technical sessions, while an imminent Fellow of the Society, Prof. Martins A. Anetekhai Ffs, presented a well-articulated keynote address titled “National Insecurity and Challenges of Fish Production: the role of public and industrial sectors.” The paper was discussed by Prof. Jude Momoh who discussed on the security aspect, while Dr. Aminu Raji who discussed on the Fish production aspect which has direct linkages with Lake Chad and insecurity in north east due to loss of over 50% of water bodies. The paper was further discussed by Dr. Abba, Y. Abdullah, Special Adviser on Agriculture to Katsina State Governor who agreed with the position of Dr. Aminu Raji. The address of the Governor, His Excellency, Rt. Hon. Ahmadu Umaru Fintiri was delivered by his representative, Professor Maxwell Gidado, the Chief of Staff to the Government House.

ANNUAL GENERAL MEETING, ELECTION OF NEW NATIONAL EXECUTIVE COUNCIL MEMBERS AND 2023 HOSTING STATE

Annual General Meeting (AGM) of the Society and election of the new executive council members were held successfully. Dr. Ebinimi J. Ansa Ffs, an active member of Rivers State Chapter was elected as the President of the Association. Others elected into the National Executive Council were:

- xiii. Dr Olalekan R. Oguntade, Vice President (Fisheries Institute (FIN) & Linkages)
- xiv. Dr Abdullahi Orire, Vice President (Industries)
- xv. Dr Philip I. Ifejika, Vice President (Aquaculture)
- xvi. Prof. Olukayode A. Sogbesan (Vice President, Research and Training)
- xvii. Dr Babangida Abdulkarim, National Secretary
- xviii. Prof. Aduabobo I. Hart, National Editor
- xix. Princess Victoria O. Ojelade, National Treasurer
- xx. Prof. Keziah V. Absalom, Financial Secretary
- xxi. Mr. Elliot Faminu, Public Relations Officer
- xxii. Dr Sampson Ohaturuonye, Assistant National Secretary

States having interest to host 2023 Annual Conference were advised to write to the Secretariat for discussion and approval by the NEC members.

POST CONFERENCE RECOMMENDATIONS AND CONCLUSIONS

The main recommendations, conclusions arising from the sessions and the final deliberations at the FISON 2023 Conference held at Yola, Adamawa State are as follows:

1. Environmental degradation, ignorance, poor governance and political issues were cited to be the major problems that caused national insecurity.
2. There is urgent need to apply good governance in order to solve insecurity in the country.
3. The participants were alerted on the growth of invasive seaweed known as Sargassum species in our water bodies and the need to use it as part of fishery value chain.
4. There must be an effective Public-Private Partnership (PPP) aimed to mobilize resources in order to improve on security, academic and research activities in the fishery sector.
5. The need to adjust the fishery and aquaculture curricula or syllabi of our tertiary institutions to reflect the need of the industrial sector.
6. It is established that fisheries data generation and management is very poor and need holistic approach to improve fisheries data in Nigeria.
7. There is the need for the revival of fisheries statistics committees for the States and Federal Government.
8. There is the need for partnership between FDF, NITDA and States for the development of FISH DAS software.
9. There must be a positive change of attitude to work by State Chapter officials as well as NEC especially in the areas of commitment to work, dedication to duties, integrity, punctuality and strict discipline.
10. There is the need to monitor the activities of the state chapters in order to motivate them and make them more active.
11. FISON applauded the contribution of Adamawa State Government in boosting the Fishery and Aquaculture sub-sectors. For instance, establishment of State Ministry for Livestock and Aquaculture Development and full support to FISON Adamawa State to host 2022 Conference of the Society.

Signed:

Dr. Ebinimi J. Ansa Ffs
National President (FISON)

Key Note Address

NATIONAL INSECURITY AND CHALLENGES OF FISH PRODUCTION: THE ROLE OF PRIVATE AND INDUSTRIAL SECTORS

DISTINGUISHED PROFESSOR ANETEKHAI MARTINS

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VISION

To make Nigeria a secure, safe, just, peaceful, prosperous and strong nation

MISSION

To apply all elements of national power to ensure physical and human security, a just society, peaceful co-existence, national unity, prosperity and sustainable development while promoting Nigeria's influence in regional, continental and global affairs.

National Insecurity

National inability/ lack of the capacity to

- ▶ mobilize military forces to defend its borders
- ▶ deter or successfully defend against physical threats including military aggression and attacks by non-state actors, such as terrorism
- ▶ protect its citizens, polity, economy, institutions, environment etc,

National insecurity challenges leading to insufficient yield.

1. TERRORISM AND VIOLENT EXTREMISM (input, production, markets and marketing)
2. ARMED BANDITRY, KIDNAPPING, MILITANCY AND SEPARATIST AGITATIONS (input, production, markets and marketing)
3. PASTORALISTS AND FARMERS CONFLICTS(Aquaculture input)
4. TRANSNATIONAL ORGANISED CRIME(Market and marketing)
5. PIRACY AND SEA ROBBERY (Industrial fisheries)
6. POROUS BORDERS (input and marketing)
7. CYBERCRIMES AND TECHNOLOGY CHALLENGES (trade)
8. SOCIO-POLITICAL THREATS (inconsistency in policy and entire fisheries and aquaculture value chains)
9. FAKE NEWS AND HATE SPEECH (production and marketing eg catfish is fatty)
10. ENVIRONMENTAL THREATS (fisheries and aquaculture value chains)

11. PUBLIC HEALTH CHALLENGES (Production and marketing)
12. ECONOMIC CHALLENGES (entire fisheries and aquaculture value chain)
13. Energy Deficit (fisheries and aquaculture value chains)
14. Crude Oil Related Crimes (pollution and affects fisheries and aquaculture)
15. Unemployment and Poverty (Entire fisheries and aquaculture value chains)
16. Global Economic Challenges (fisheries and aquaculture value chains)
17. REGIONAL AND GLOBAL SECURITY CHALLENGES (inputs, production and trade)

NATIONAL INSECURITY CHALLENGES LEADING TO INSUFFICIENT YIELD	INPUT	PRODUCTION	MARKETS	MARKETING	AQUACULTURE	INDUSTRIAL FISHERIES	TRADE	INCONSISTENCY IN POLICY	POLLUTION	Total
Terrorism and Violent Extremism	5	5	5	5	5	5	5	-	-	35
Armed Banditry, Kidnapping, Militancy and Separatist Agitations	5	5	5	5	5	5	5	-	-	35
Pastoralists and Farmers Conflicts	5	-	-	-	5	-	-	-	-	10
Transnational Organized Crime	-	-	5	5	-	-	-	-	-	10
Piracy and Sea Robbery	-	5	-	-	-	5	-	-	-	10
Porous Borders	5	-	-	5	-	-	5	-	-	15
Cybercrimes and Technology Challenge	-	-	-	-	5	5	5	-	-	15
Socio-Political Threats	5	5	5	5	5	5	5	5	-	40
Fake News and Hate Speech	-	5	-	5	-	-	-	-	-	10
Environmental Threats	5	5	5	5	5	5	5	5	-	40
Public Health Challenges	5	5	5	5	5	5	5	-	-	35
Economic Challenges	5	5	5	5	5	5	5	-	-	35
Energy Deficit	-	-	-	-	5	5	-	-	-	10
Crude Oil Related Crimes	-	-	-	-	5	5	-	-	5	15
Unemployment and Poverty	-	-	-	-	5	5	-	-	-	10
Global Economic Challenges	-	-	-	-	5	5	-	-	-	10
Regional and Global Security Challenges	5	5	-	-	-	-	5	-	-	15
Total	45	45	35	45	60	60	45	10	5	350

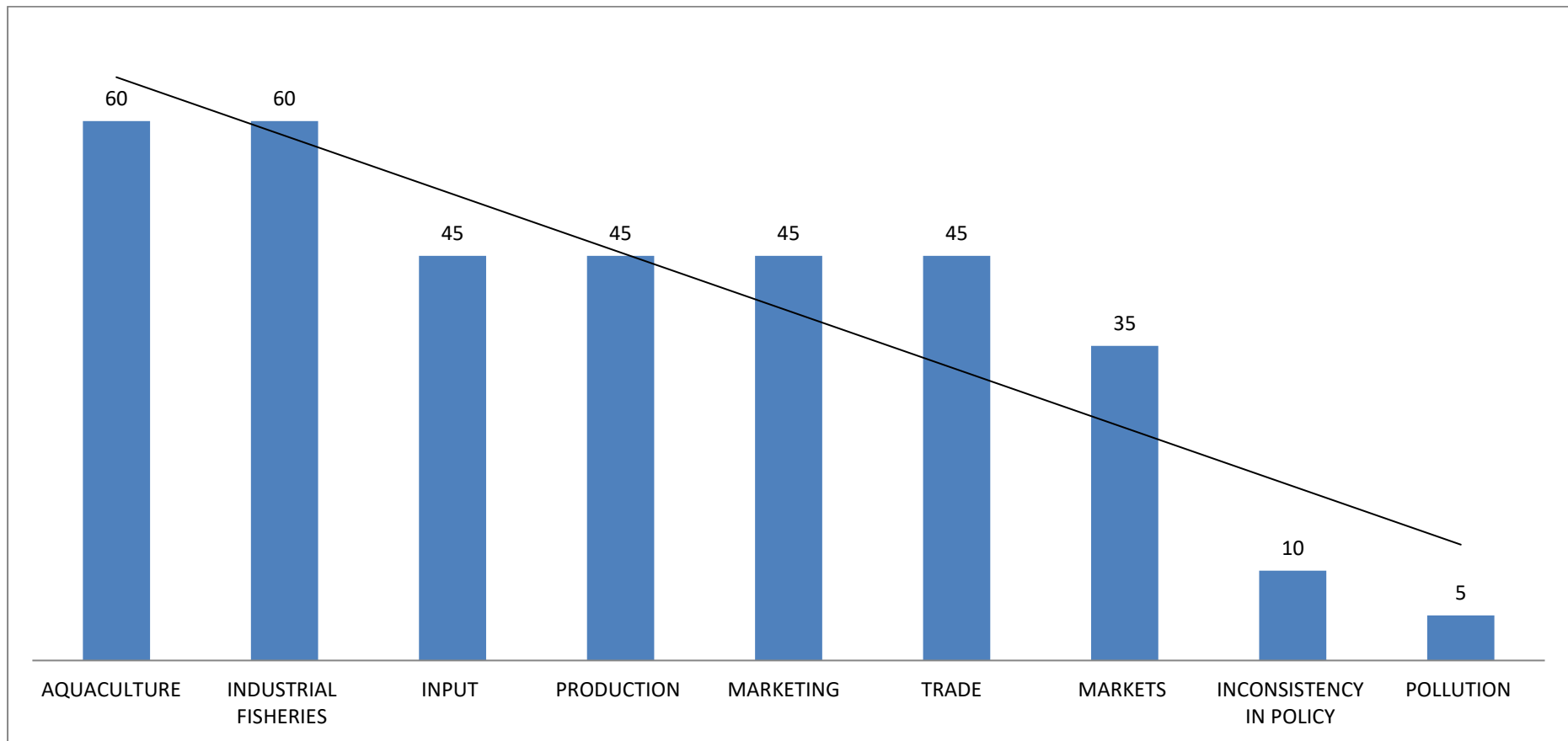


Figure 1: Challenged aspects of the Value Chain

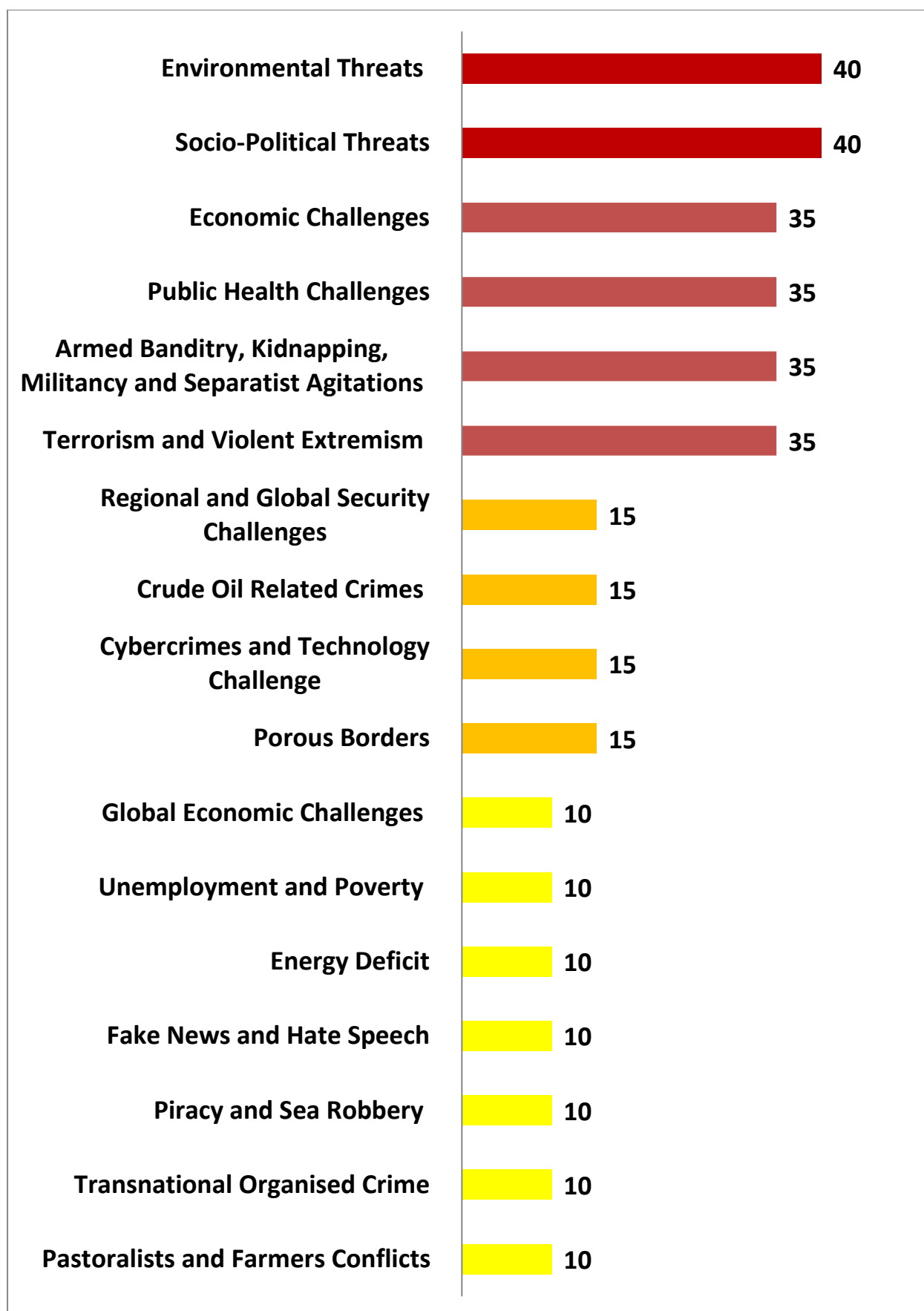


Figure 2: IMPACTS OF THE IDENTIFIED CHALLENGES

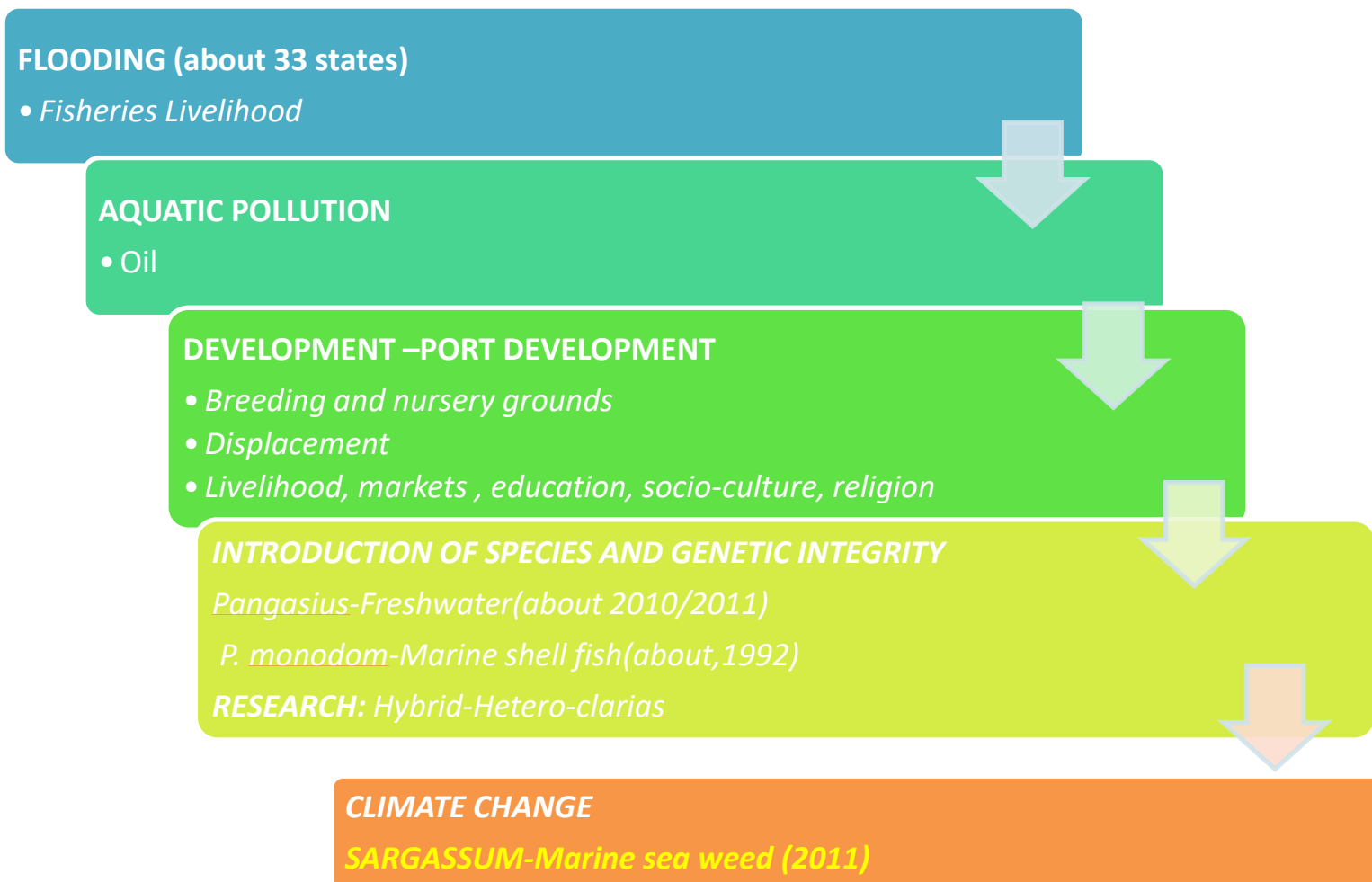


Figure 3: Environmental Insecurity



Pangasius: Culture and uses are on going going:\$50M



***Penaeus monodon*: culture and marketing on**



Sargassum in Nigeria Beach- Resource



Ilaje community with Sargassum natural resource

Enroachment of Sargassum.

- ▶ First Seen around 2010/2011 in Nigerian territorial waters.
- ▶ Blooms about March and disappears around August.
- ▶ This weed is believed to have drifted from the Sargasso Sea and now covers all the West coast of Africa.
- ▶ South Africa, the Caribbean Islands, etc.

Challenges Sargassum

- ▶ Prevents artisanal fishermen and women whose livelihoods depend on the marine waters (0 to 5 nautical miles) from fishing and carrying out other activities which they rely on for their livelihood(73) such as transportation and tourism.
- ▶ In addition, the marine trawlers targeting shrimps in the area beyond the 5 nautical miles for export are affected.



Sultan Beach, Badagry, Lagos State

Strategy 1: CENTRE OF EXCELLENCE FOR SARGASSUM RESEARCH

World Centre of excellence in Sargassum Research-baseline Data on Sargassum and Entrepreneurship

Strategy II: Take up the leadership in the utilization of *Sargassum* for the empowerment of fishing communities in Nigeria and other countries where it has hitherto been perceived as a nuisance.

- (A research project” Harnessment of Sargassum for entrepreneurship in coastal communities is on going”

Activities:

1. Publicity

- Undertake campaigns to promote the buying-in of other coastal Nations into exploration of the benefits of the *Sargassum* weed(Workshop(140 attendees from 12 countries), Proposals, etc).



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CENTRE OF EXCELLENCE FOR SARGASSUM RESEARCH INTERNATIONAL CONFERENCE

- **THEME:** HARNESSING SARGASSUM FOR ENTREPRENEURSHIP DEVELOPMENT IN COASTAL FISHING COMMUNITIES
- ALL PARTICIPANTS



Activity 2: Research

Harnessment of Sargassum for entrepreneurship in coastal communities

LASRIC FUNDED RESEARCH

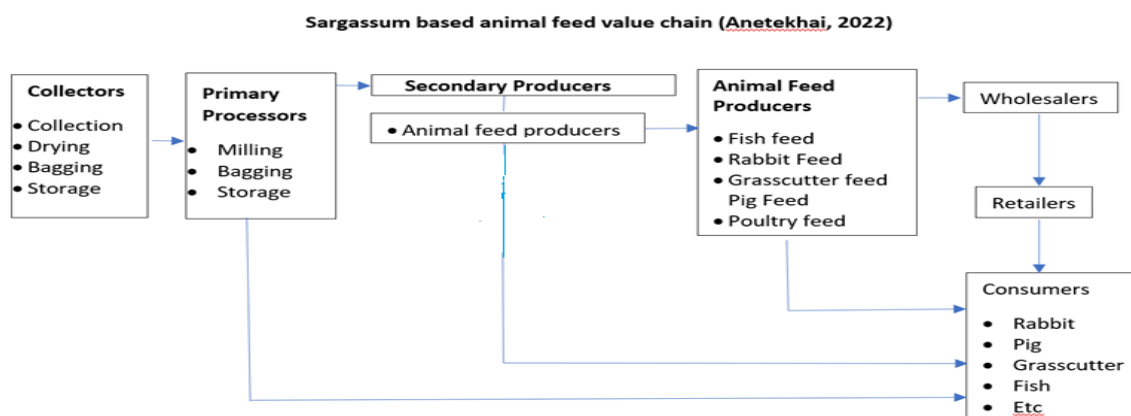
- ▶ Examine the taxonomy, geography, and distribution of the *Sargassum* worldwide.
- ▶ Evaluate the impact of the *Sargassum* weed on fisheries and other means of livelihood in the coastal communities.
- ▶ Explain the economic, medicinal, and other values of the *Sargassum* weed.
- ▶ Assessment of presence of electricity generating material or otherwise from sargassum and application of it for generating light and other power required to run livelihood in fishing communities

Sargassum in a warehouse

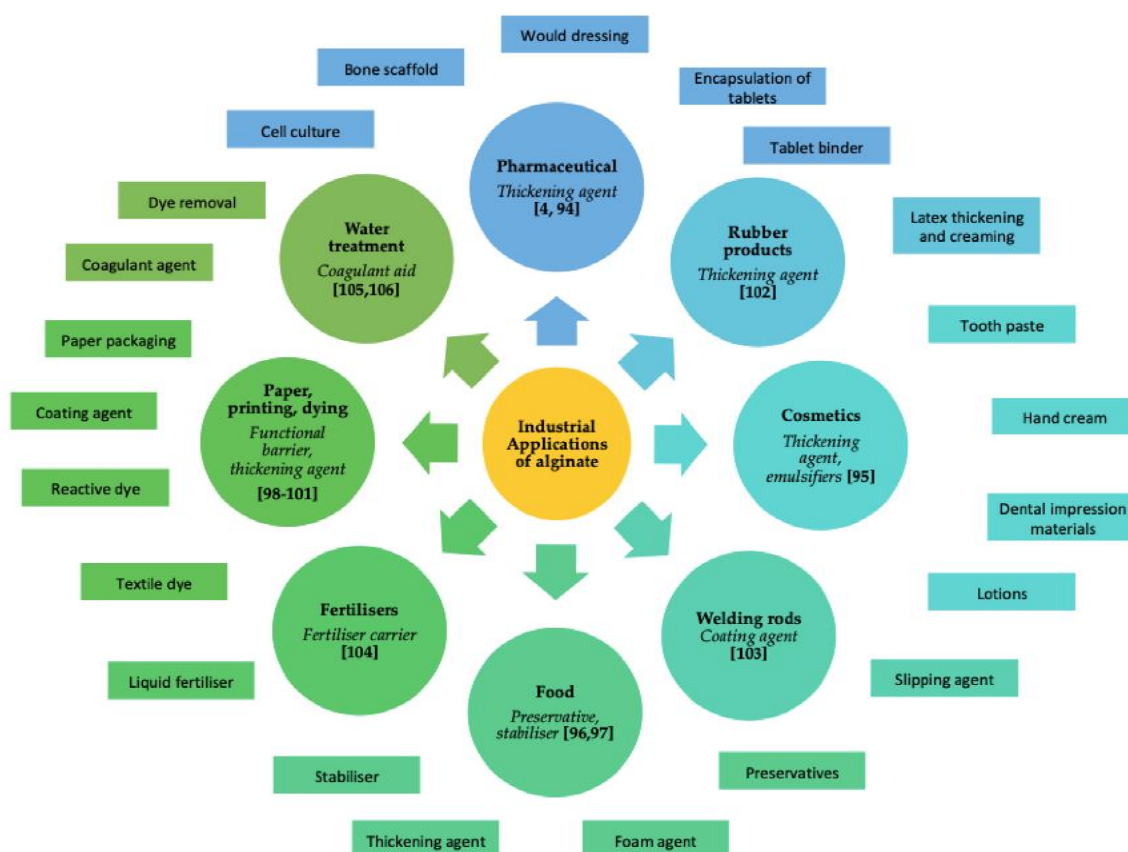


SARGASSUM VALUE CHAINS

Sargassum value chain (Fisheries and Aquaculture)



INDUSTRIAL APPLICATIONS OF ALGINATE



Private and Industrial

- ▶ The private sector creates the jobs, goods and some of the services that the world's poorest people so desperately need to lift themselves out of poverty.
- ▶ The public sector provides the enabling environment to achieve these goals

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- ▶ Innovative Public-Private Partnership (PPP) models in aquaculture and the capture fisheries can provide solution to Inadequacies of technology, finance and human resource capacities for food security, employment and economic growth.

The role of Private and Industrial Sectors

Isolating their roles will not help it has to be a collaboration: Public-Private Partnership (PPP)

A collaborative relationship between public sector institution(s) and private sector(s) aimed at harnessing and optimizing the use of all available resources, knowledge and facilities required to promote efficient, effective, affordable, accessible, equitable and sustainable delivery of services (Obinna et al, 2022).

- ▶ In recognition of the importance of PPPs in increasing the contribution of the fisheries and aquaculture sector to socio-economic growth in the member states of the African Union, the second Conference of African Ministers of Fisheries and Aquaculture (CAMFA):
- ▶ Urged regions and member states to establish mechanism for active involvement of private sector in research and extension;
- ▶ Recommended that AU, RECs Member States to develop innovative approach for increasing private sector investment in fisheries and aquaculture.

Practical Guide to Public-Private Partnership (PPP):ECOWAS

ECOWAS-EU-FAO programme on “Food and Nutrition Security Impact, Resilience, Sustainability and Transformation programme (FIRST)” with the collaboration of ECOWAS-EU programme on “Improved Regional Fisheries Governance in Western Africa (PESCAO)” emphasized same and a West African version now exist



International framework

The ECOWAS-MS relative recognition of PPP categories listed in the World Bank's PPP Reference Guide Version 3, 2017; a compendium of international practices and views on PPP

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World Bank's PPP categories	ECOWAS-MS that recognizes category	Regional %
Design-Build-Finance-Operate-Maintain	Burkina Faso; Ghana	13.33
Design-Build-Finance-Operate		
Design-Construct-Manage-Finance		
Build-Operate-Transfer	The Gambia; Ghana; Guinea Republic; Nigeria	26.66
Build-Own-Operate-Transfer	Ghana	6.66
Build-Transfer-Operate	Ghana	6.66
Rehabilitate-Operate-Transfer	Ghana	6.66
Concession	Cape Verde; The Gambia; Ghana; Guinea Republic; Liberia; Nigeria	40
Private Finance Initiative		
Operations and Maintenance	Ghana	6.66
Affermage		
Management Contract	Cape Verde; The Gambia; Nigeria	20
Franchise		

Continental framework

The ECOWAS-MS relative recognition of PPP categories listed by the African Union in the publication arising from a meeting of African experts (in Yaoundé, Cameroun, December, 2015) titled: *A guide for developing and implementing Public-Private Partnership models for sustainable Fisheries and Aquaculture development in Africa* (AU-IBAR, 2019)

African Union's PPP categories	ECOWAS-MS that recognizes category	Regional %
Management / service contracting or outsourcing	Cape Verde; The Gambia; Nigeria	20

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Leases	Cape Verde; The Gambia; Guinea Republic; Nigeria	26.66
Concessions	Cape Verde; The Gambia; Ghana; Guinea Republic; Liberia; Nigeria	40
Build, Operate and Transfer arrangements	The Gambia; Ghana; Guinea Republic; Nigeria	26.66
Joint Venture arrangements		

Other categories

Apart from the categories from the international and continental frameworks above, analysis shows that some other PPP categories are recognized by ECOWAS-MS

Other PPP categories	ECOWAS-MS that recognizes category	Regional %
Delegated public service	Guinea Republic	6.66
Partnership agreements	Guinea Republic	6.66
Build, Operate, Own	The Gambia; Ghana	13.33
Design, Build, Operate	The Gambia	6.66
Design, Build, Operate, Finance	The Gambia	6.66
Privatization	The Gambia	6.66
Design, Operate, Transfer	Ghana	6.66
Design, Finance, Maintain	Burkina Faso	6.66
Design, Build, Finance, Maintain	Burkina Faso	6.66

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Legislations and Policy Framework on PPP in the Region

The relative status of PPP legislations and agencies among ECOWAS-MS is summarized in Table 3 below:

Member State	PPP related Legislations		PPP Regulatory Agencies	
	Number	List the PPP legislations in your country	Number	List the PPP agencies in your country
Benin	7	Loi n° 2001-07; Loi n° 2009-02; Decrees Nos. 2018-028, 039, 156, 360, 424	1	Cellule d'appui aux PPP (PPP Unit)
Burkina Faso	4	Law n° 020-2013/AN of 23 May 2013, Decree n° 2014 – 024 /PRES/PM/MEF of 03 February 2014, Decree n°2014-628/PRES/PM/MEF of 29 July 2014, Order n°2014-0263/MEF/ of 28 July 2014	2	Direction des Partenariats Publics Privés in the Direction Generale de la Cooperation & PPP Committee in the Prime Minister's Cabinet
Cape Verde	1	Decree-law no. 63/2015	1	Unit for State Business Sector Monitoring (UASE)
Cote D'Ivoire	2	Decrees Nos. 2018-358 & 359 of March 29, 2018	1	The CNP-PPP
The Gambia	None	National PPP Policy being used in conjunction with Public Procurement Act and Public Procurement Regulations temporarily until a law is enacted	1	Directorate of PPP (PPP Unit), Ministry of Finance and Economic Affairs
Ghana	2	PPP Act, 2020 (Act 1039)	1	Advisory Unit in the Public Investment Division of the Ministry of Finance
Guinea Bissau	1	???	1	Ministres de economie?
Guinea Republic	3	Decret D / 2017 / 278 / PRG / SGG; Decret D / 2021 / 041 / PRG / SGG; Decret D / 2021 / 041 / PRG / SGG	1	PPP Unit, The Presidency
Liberia	2	Public Procurement and Concessions Act; National Bureau of Concessions Act	1	National Bureau of Concessions
Mali	3	LOI N° 2016 – 061/DU 30 DEC 2016; Convention de Financement; and DECRET N°2015-0604/P-RM DU 25 SEPTEMBRE 2015	1	Une unite PPP rattache à la Primature
Niger	1	Draft PPP law (2014) has not yet been adopted	2	Cellule d'appui au Partenariat Public Privé (CAPPP), Prime Minister's Office & Division of Public Procurement and Management of Public Service, President's Office
Nigeria*	2	ICRC (establishment, etc.) Act, 2005 & Public Procurement Act, 2007	1	Infrastructure Concession Regulatory Commission (ICRC)
Senegal	2	PPP Contracts Law & PPP Law and Application Decree	4	PPP Unit, PPP National Committee and Directorate of Finance and Public-Private Partnerships, Ministry of Investment Promotion and Partnerships; Infrastructure Council; APIX S.A
Sierra Leone	1	PPP Act 2014	1	PPP Unit, President's Office
Togo	1	Law is under review	None	Not applicable

Notes: (1) Some subnational (state and local governments) governments have their own PPP laws and agencies apart from the federal laws and agency listed here

RECOMMENDATIONS

- Relocation (capture fisheries) and rehabilitation(aquaculture): opportunity for cluster farming, social cultural considerations, skills and entrepreneurship, start ups
- Restructuring; Ministry of Fisheries and Aquaculture
- Alignment and adoption of AU policy framework and reform strategy
- Domesticating and operationalizing the Continental and Regional PPP as recommended by AU and ECOWAS.
- Introduction of fisheries and aquaculture entrepreneurship to our curriculum at all levels
- Innovative transformation of environmental insecurity to wealth

CONCLUSION

- he Nation is not secured in all aspects and this has impacted negative on our fish production output
- Aquaculture which is under the control of man stands out as the hope of the Nations to meet fish required for consumption and industrialization.
- To achieve success, it has to be private sector driven and market-led using value chain approach in all suitable areas.

Lead Paper

Fisheries Governance Strategies for Effective Sector Administration in Nigeria

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Overview of Nigerian Fisheries Governance Structure

- Government administrative structures: Federal and States Responsible for Nigeria Fisheries Management
- Supporters: Research Institutes Tertiary Institutions - responsible for research and human resources development.
- Non-government organisations: Limited input in governance process.
- Water bodies extending in more than one state, fisheries resources entrusted to the Federal Department of Fisheries in the Federal Ministry of Agriculture and Rural Development.
- Intra water bodies are under the responsibility of States, Local Governments, Communities or agencies

Situation?

- Absence of clear policy guidelines,
- extant policy and laws are out dated and the instruments not in tune with modern trends of fisheries regulations.
- Enforcement of out dated laws inadequate sustainable fisheries practices.
- The legal framework for these oversight functions where Agriculture, and by extension fisheries is placed under the concurrent legislative list.
- Conflict between the two tiers of government often arise in the management of the sector, however, “should a provision of State law conflicts with that of a Federal law on a matter, the provision of the Federal law shall prevail, and the provision of the State law shall, to the extent of its inconsistency, be void” (1999, Nigerian Constitution).
- Federal Fisheries Laws, therefore, take precedence over State laws especially for trans boundary water bodies.

Institutions Stakeholders

- 1) Fisheries Research Institutes; National Freshwater Fisheries Research Institute (NIFFR) and Nigerian Institute for Oceanography and Marine Research (NIOMR) - some level of fisheries management responsibilities.

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- 2) Broad mandate includes: provision of research support, policy advice and some extension services in fisheries.
- 3) Federal and States' Universities with full-fledged Departments of Fisheries and Aquaculture and three Federal Colleges of Fisheries at Lagos, New Bussa and Baga-Maiduguri involve in research but more involved in human capital development.
- 4) The Agriculture Research Council of Nigeria (ARCN) coordinates activities of these institutions.
- 5)
- 6) Nigerian Navy and Nigeria Maritime Administration and Safety Agency (NIMASA): security and ensure safety in the Nigeria territorial waters;
- 7) National Food and Drugs Administration and Control (NAFDAC) in charge of food safety and quality control,
- 8) Nigerian Ports Authority and The Inland Water Ways Department for effective marine vessels traffic in the Nigeria waters.

Professional Bodies and Non-Governmental Organisations

Fisheries Society of Nigeria (FISON) is the umbrella professional body for the fisheries sector. Operating under its professional responsibilities are the producer organisations and NGOs within the fisheries sector. These include among others:

- Nigerian Trawler owners Association (NITOA)
- Association of Fish Farmers and Aquaculturist, Nigeria (AFFAN)
- Catfish Farmers Association of Nigeria (CAFAN)
- Tilapia Aquaculture Developers Association, Nigeria (TADAN)
- Nigerian Union of Fishermen and Seafood Dealers (NUFAS)
- Association of Fish Importers of Nigeria (AFIN)
- Association of Ornamental Fish Exporters of Nigeria (AOFEN), etc.

Traditional authorities:

- informal institutions play important role in the management of artisanal fisheries.
- Traditional authorities play significant roles in the control and management of artisanal fisheries in Nigeria, even in the absence of any formal transfer of power to them by Central government.

Fisheries Governance Legal and Regulatory Framework

Fisheries Policy

- Federal Government: overall goal of achieving increased domestic fish production from all sources (coastal/marine, inland water, industrial and aquaculture).
- Focuses on conservation, employment generation, wealth creation, poverty alleviation and reduction in rural-urban migration.

Specific Objectives:

- 1) Self-sufficiency in fish production.
- 2) Development and modernization of the means of production, processing, storage, marketing and resources conservation.
- 3) Promotion of exports of shrimps and fish products.
- 4) Improvement on the quality of life in fishing villages.
- 5) Provision and improvement of employment opportunities in the rural fishing communities.
- 6) Acceleration of Research and Technology dissemination and adoption.
- 7) Ensuring rational exploitation of the nation's marine fisheries resources.
- 8) Human capacity development through improvement and development.
- 9) Promotion of fisheries curricula in the institutions of higher learning.
- 10) Encouragement of private entrepreneurship in all aspects of fisheries.
- 11) Ensuring total compliance with the FAO's Code of Conduct for Responsible Fisheries (CCRF).

The promulgation of this policy was however carried out without adequate consultations with all the relevant stakeholders in the industry to the extent few are aware of its existence and the name 'National Fisheries Policy' is often viewed by many as Federal Fisheries Policy.

Nigeria Fisheries Governance Process

- 1) National Fisheries Development Committee (NFDC) which is a committee of the National Council on Agriculture (NCA)- highest policy making body
- 2) Membership: Federal Director of Fisheries (chair)s, State fisheries Directors and representation from Professional bodies, NGOs and the industries.
- 3) NFDC is the level where policies and programmes are finalized for Government approval for implementation.

Nigeria's Regulatory Laws:

- 1) Exclusive Economic Zone Decree No. 28 of 1978.
- 2) Sea Fisheries Decree No. 71 of 1992.
- 3) Sea Fisheries (Licensing) Regulations of 1992.
- 4) Sea Fisheries (Fishing) Regulations of 1992.
- 5) Inland Fisheries Decree No. 108 of 1992.
- 6) Sea Fisheries (Fish Inspection and Quality Assurance) Regulations of 1995.
- 7) Inland Fisheries (Fish Quality Assurance) Regulations of 1995.

- 8) Turtle Excluder Device Regulations of 1996.

Laws main objectives include:

- 1) Increased fish production through input supply at subsidized rate.
- 2) Technology transfer and revolving loan schemes for fishermen.
- 3) Sea Licensing/Fishing Regulations
- 4) Control and regulate coastal and industrial fisheries.
- 5) Provide research support, policy advice and some extension services in fisheries,
- 6) Management and conservation of fisheries resources
- 7) Prohibition of unauthorized export or import of live fish; and
- 8) Protection of fish products from contamination and infection.

Fisheries laws

Enforcement Challenges:

- 1) lack of ownership,
- 2) lack of political will,
- 3) underplaying the relevance of fisheries to the Nigeria economy,
- 4) Low budgetary allocation,
- 5) Lack of human resources,
- 6) Lack awareness of its existence,
- 7) Lack of awareness to the environment impact of unregulated fishing practices, etc.

Results:

- 1) excessive fishing pressure,
- 2) pollution,
- 3) siltation and weed infestation,
- 4) destructive fishing practices
- 5) Loss of biodiversity,
- 6) Low productivity,
- 7) Poverty among the fishing population,
- 8) Reduced nutritional intake among poor Nigerians,
- 9) Security challenges, etc.

Nigeria Fisheries Act 2014

- European Commission commissioned the review and update of both the Sea and Inland Fisheries Acts in 2012 and 2013.
- Aim to ensure sustainable management of fisheries resources based on modern management instruments.
- The Fisheries Act 2014 was developed and approved by the Commission and forwarded to the Federal Government for enactment.
- Repeals Sea Fisheries Act (No. 78 of 1992) and the Inland Fisheries Act (No. 108 of 1992)
- Provides for the conservation, management and development of sea fisheries, inland fisheries and aquaculture and related matters.

Objectives

1. to promote optimum utilisation and long-term conservation, management and sustainable development of fisheries resources and ecosystems in all fisheries waters;
2. Recognising the needs of present and future generations need in resources utilization for food and nutritional security, economic growth, human resource development and employment creation.

Scope

1. Management and control of sea fisheries
2. Management and control of inland fisheries
3. Management and control of aquaculture

Authority of the Minister

1. Responsible for management and development in Nigeria and in fisheries waters,
2. Preparation and implementation of policy and further legislation necessary for proper functioning and development of the sector.

Ministry:

1. Promulgates and coordinate policies in relation to fisheries,
2. coordination and liaison with relevant stakeholders within and outside Nigeria; and
3. recommendations to the Minister on fisheries policy; and
4. recommendations on the performance of any of his or her powers, duties or functions under this Act;

Fisheries Commission

1. There shall be a Fisheries Commission under the Act
2. responsible for regulating and managing the exploitation, conservation, management and sustainable development of fisheries resources
3. exercise such competence as is accorded to it by or under this Act in relation to sea fisheries, inland fisheries and aquaculture;

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4. responsible for matters of enforcement of fisheries standards, regulations, rules, laws, policies and guidelines;

Functions of the Commission

- 1) long-term conservation, management and sustainable utilisation of fisheries resources;
- 2) conservation, management and development practices based international standards and best practices
- 3) taking into account the particular rights, interests and needs of artisanal and subsistence fishers;
- 4) adoption of integrated approaches to fisheries and other ocean and inland waters management,
- 5) implementation of good governance, accountability and transparency and involving fisheries stakeholders and fishing communities in all levels of decision-making;
- 6) cooperation with other public agencies, to implement and enforce compliance with the provisions of international agreements, protocols, conventions and treaties on fisheries and aquaculture;
- 7) implement and enforce management and control measures through registration, licensing and permitting systems;

Functions of the Commission

- 1) undertake, coordinate, utilize and promote the expansion of research, experiments, surveys and studies by public or private agencies, institutions and organizations concerning fish, fisheries and fishing operations;
- 2) collect and share data on fisheries and aquaculture, information from national and international research programmes;
- 3) promote sustainable trade in fish and fishery products,
- 4) application of international standards and rules on post-harvest practices, trade and sanitary and phytosanitary systems
- 5) marketing collaboration with other relevant agencies,
- 6) Establishment of programmes for setting standards and regulations for the maintenance, restoration and enhancement of the nation's fisheries resources.

Functions of the Commission

- 1) enforce compliance with laws, guidelines, policies, standards and other conservation and management measures,
- 2) coordinate and liaise with stakeholders, within and outside Nigeria;
- 3) create public awareness and education on sustainable fisheries management
- 4) minimise and resolve disputes between individuals in the fisheries sector

- 5) take into account any relevant recommendations of the Ministry and the National Fisheries Stakeholder Forum.

Legal status of the Commission

This shall be a body corporate with perpetual succession and a common seal; and may sue and be sued in its corporate name.

1. Commission's Governing Council

The membership of the Council shall consist of—

- Director General, who shall act as the secretary to the Council;
- one representative each of—
 - Ministry Agriculture;
 - Ministry of Water Resources;
 - Ministry responsible Environment;
 - Ministry of Transport;
 - National Planning Commission;
 - Nigerian Navy;
 - Marine Police;
 - Fisheries Based Research Institutes,
 - Representatives from State Government, (Coastal State inland States)
 - President of Fisheries Society of Nigeria; and
 - two other persons nominated by the President.

National Fisheries Stakeholder Forum

- consultation between the Minister, the Commission, the Council and stakeholders from the fisheries sector;
- reviewing the implementation of this Act, including as appropriate through the development of a strategy or strategies for its implementation;
- reviewing proposals for new or amended policies, fisheries management plans, legislation or other conservation, management and development measures; and
- making recommendations to the Minister or to the Commission on current or proposed policies, fisheries management plans, legislation or other conservation, management and development measures.

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Forum Membership

- 1) Director General,
 - 2) Technical Directors of the Commission;
 - 3) Representative of the Ministry
4. a representative from each of–
- Marine Police;
 - Nigerian Maritime Administration and Safety Agency;
 - Nigerian Navy;
 - Nigerian Oil Spill Detection and Response Agency;
 - Nigerian Ports Authority
 - the Nigerian Customs Administration;
 - National Water Resource Research Institute;
 - National Inland Water Ways Authority
- Six State Fisheries Directors, one from each of geopolitical zone of Nigeria;
5. a representative of the Fisheries Society of Nigeria;
6. two representatives of fisheries-based research institutes,
7. a representative from the academia,
8. at least four persons representing fish producer NGOs (industrial, artisanal and aquaculture, and fish processing and/or marketing industry.

Dispute Settlement Panels

- responsible for hearing and settling complaints on matters arising from or related to the fishing sub-sector.

Fisheries Development Fund.

Monies for the Fund shall consist of :

- a. damages, costs and compensation granted by the Courts to the Government in respect of an action under this Act or regulations under it;
- b. sums of money received for compounded offences;
- c. proceeds of the sale of forfeited items collected, imposed or received by or under this Act;

- d. amount of money that the Council may approve for payment into the Fund, from the Management Fund;
- e. the amount of money that Government may approve for payment into the Fund; and
- f. loans and grants.
- g. Monies held by the Commission on behalf of affected persons under the Act in fraction, though not form part of the Fund.

The monies of the Fund shall be applied –

- a) promotion and development of fisheries in the country;
- b) establishment and implementation of co-management agreements and fisheries management plans;
- c) meeting the liabilities of the Commission in respect of the monitoring, control and surveillance of the fishery waters, including the operation of VMS;
- d) assistance to artisanal fishers;
- e) research, studies and data programmes; and
- f) any other purposes determined by the Council in consultation with the Minister.

ACT INSTRUMENTS

1. Co-management
2. Determination of total allowable catch or effort
3. Determination of participatory rights
4. Designation of fishing zones
5. Closed seasons and closed areas
6. Marine reserves
7. Prohibited fishing methods and practices
8. Capture of marine mammals and sea turtles
9. Registration of fishing
10. Registration of Vessels
11. Prohibition on fishing without a licence
12. Authorisations for marine scientific research and experimental fishing

13. Closed seasons and closed areas
14. Prohibited fishing methods and practices
15. Prohibition of removal of fish from nets, traps, etc.
16. Maintenance of access to inland fisheries waters and landing sites
17. Control on construction of dams, weirs, barriers, etc
18. Restriction on use of fishing gear, etc.
19. Identification mark on fishing craft
20. Declaration of catch, etc

Regulation of aquaculture Practices

- a) location and nature of the aquaculture operations;
- b) fish or other aquatic organisms to be cultivated or not to be cultivated;
- c) the source of the stock;
- d) construction of the aquaculture facilities and the operation of those facilities and measures in place to prevent the introduction of alien species;
- e) use of appropriate antibiotics, other drugs and chemicals;
- f) prevention of the spread of communicable fish diseases; and
- g) inspection of aquaculture sites and facilities;
- h) disposal of waste water and other farm wastes;
- i) provision of statistical, scientific and commercial information; and
- j) conservation, management and sustainable use of the aquatic environment;
- k) other permits that maybe required by other agencies

1. Similar Commissions in Nigeria (37nos)

- a) Nigeria Communication Commission
- b) National University Commission
- c) Universal Basic Education Commission
- d) Energy Commission of Nigeria
- e) Nigeria Electricity Regulatory Commission
- f) Nigeria Investment Promotion Commission
- g) Nigeria Broadcasting Commission
- h) Integrated Water Resources Commission

- i) Federal Road Safety Commission
- j) Niger Delta Development Commission; etc.

2. Fisheries Commissions in Other Countries

- a) Ghana
- b) Kenya
- c) Mauritania

FISON CHARTER BENEFITS

1. The payment of professional salaries to all private and public sector employed fisheries staff nationwide.
2. The formal inclusion of FISON into the APBN.
3. The finalisation of the collaboration formalities (MOUs) Training Schedules, etc of the NAFDAC/FISON and operational certifications/endorsements of all projects/programmes/production centres, etc within the Fisheries sub-sector.
4. The provision of formal professional training and appointment of consultants (alongside the issuing of professional stamps) from the ranks of qualified FISONITES under the coordination of FIN.
5. The multivariate operational and financial achievements/opportunities accessible to the varied affiliates of FISON within the Fisheries sub-sector.
6. The improvement of the overall production and service delivery outlook of the Fisheries sub-sector to the added advantage of the Nigerian economy.
7. The review and improvements of the implementation of major National Fisheries statutory projects/programmes/publications.
8. Development of appropriate curriculum that reflects the needs of the industry
9. Budgetary allocation to the FIN by Federal Government

CONCLUSION

- The Charter takes care of human capital development of the sector, i.e. professionalism.
- The commission take ensures sustainable and profitable operations that will ensure the food, nutrition and industrial supplies of the fisheries sector.
- It is therefore obvious that Fisheries Sector needs both the Charter and the Commission

SPECIAL PAPER

CHALLENGES OF FISHERIES DATA MANAGEMENT IN NIGERIA

Dr. Abubakar, Jerima Yaji

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Fisheries Data Management in Nigeria

*What type of Fisheries Data?

*What are the methods of data collection?

*What are the analytical methods of national fisheries data?

All the above questions are critical to have a unified system of data collection, collation, retrieval and dissemination of fishery data that will be accepted by international organizations such as FAO and regional organizations such as ECOWAS and FCWC.

-Fishery data such as catches by sectors and species, fish price data (weight/unit), quantities harvested (catch), the fishing efforts etc are all primary fishery data

Unified data collection and analytical methods are key problems that need to be address by all fisheries stakeholders to avoid variability and discrepancies of fishery data

Unified data collection, storage and dissemination will serve as source of information for national planners, policy makers, researchers and consultants of fishery sector

CHALLENGES

- Insufficient trained personnel in data collection in all or most of the states of the federation
- Insufficient funds to facilitate data collection and interpretation
- Lack of national fishery data system to enhance retrieval and dissemination
- Insecurity
- Environmental pollution

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Credit to FDF that presented a memo and approved by National Council of Agriculture (NCA) to develop software called FISHDAS with the following objectives:

- To establish a reliable data collection system that will be cost effective and ICT- based for easy access to stakeholders
- To ensure that data collected meets international best standards that will be acceptable by bodies like FAO and FCWC
- To enable Nigeria manage her fish resources optimally

However, critical to the development of the software is technical staff to be engage in data collection from the states. There should be therefore be a collaboration between FDF, states, non-state actors' academia and NGO's to play the role of advocacy

CONCLUSION

- Variability in National Fisheries data collection and dissemination
- There should be a partnership between federal, states, academia, non- state actors and NGO's
- Revival of statistical committees at federal and state levels
- For robust development of FISHDAS, FDF should partner with the states

AQUACULTURE AND FISH NUTRITION

NUTRITIONAL EVALUATION OF PROCESSED CALABASH (*Lagenaria vulgaris*) SEED MEAL AS FISH FEEDS INGREDIENT

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ABSTRACT

The study investigated the effect of different processing methods before and after oil extraction via toasting, drying, boiling, soaking and raw calabash seed cake. Proximate and minerals analyses were carried follows standard methods. The results were subjected to analysis of variance (ANOVA) using SPSS version 20. The results showed that the moisture content of processed Un-extracted oil calabash seeds was high ($12.50 \pm 1.73\%$) in raw unprocessed and differed from other processing methods. Lipid content in toasted was ($36.80 \pm 1.41\%$) with significant differences, the same trend with crude protein with no significant ($p > 0.05$). The oil extracted cake through boiling method recorded the highest moisture content ($10.00 \pm 2.64\%$) but did not differ significantly from those of other methods. The raw Calabash meal recorded the highest lipid content ($13.15 \pm 1.00\%$) although not significantly different ($p > 0.05$) Boiling method recorded the highest crude protein (37.71%), lipid ($13.15 \pm 1.00\%$) and the lowest was reported in raw ($32.98 \pm 1.00\%$) with significant differences. The least and highest minerals values for the extracted samples were reported in toasted for Mg of the value ($0.14 \pm 0.00\%$) and Boiled for P and Fe of the value ($28.00 \pm 20.19\%$) respectively. For raw oil extracted methods were significantly different ($P > 0.05$). The study therefore recommended that all the samples analysed, the processed toasted sample before oil extracted was the best recorded in crude protein of the value ($26.60 \pm 1.00\%$) and similarly dried and Boiled samples after oil extraction were the best recorded in crude protein of the values 37.10 ± 2.00 and 37.71 ± 1.00 respectively and further investigation on biological assay through feeding trials to assess growth and nutrients utilization in cultured fish

KEYWORDS: Nutritional value, Mineral composition, *Lagenaria vulgaris* seed, processing methods

INTRODUCTION

As aquaculture production becomes more intensive in Nigeria, fish feed has always being a significant factor in increasing the productivity and profitability of aquaculture (Akinrotimi *et al.*, 2007). Commercially manufactured fish feeds are important in modern commercial fish farming, providing the balance nutrition needed by farmed fish. The feed, in the form of granules or pellets, provides the nutrients in a stable and concentrate form, enabling the fish to feed efficiently and grow to their full potential (Orire and Sadiku, 2014). Calabash plants originated from Africa and spread to Brazil (Tindall, 1983). It is an important economic crop in Nigeria, grown extensively in the semi-arid region purposely for its calabash. Saidu *et al.* (2003) reported that *Lagenaria vulgaris* is an oily leguminous plant cultivated in some part of North-western Nigeria for the ball-like “fruit” which is used as house hold containers. In the North-western states of Nigeria, it is planted between August and October. Soetan and Oyewole (2009) viewed that a means of eliminating or reducing their adverse effect to lowest and tolerable levels should be discovered. Therefore, removal of undesirable components is essential to improve the wholesome and nutritional quality of plant based diets and effectively utilize their full potential as fish feed substitutes. Generally a simple and cost effectiveness processing techniques are effective methods for achieving desirable changes in ensuring a favourable level of these nutrients composition in feed seeds (Akande and Fabiyi, 2010). There are different

processing techniques which when effectively employed will ensure a safety and wholesomeness of a product for growth and performance of cultured fish (Fagbenro, 1999 and Becker, 2003). Traditional processing techniques could effectively reduce the anti-nutritional components in legumes and oil seeds (Maron *et al.*, 1968). Heat used in the commercial processing of seeds and plant based ingredients improves protein quality by destroying certain anti-nutritional factors (Francis *et al.*, 2006).

The potential of calabash seed meal on the diet of animals including fish (Maigandi and Ngang, 2002; Mamman *et al.*, 2012; Mamman *et al.*, 2013 and Jibrin *et al.*, 2018) were carried out. Therefore, the aim of this study is to determine the nutritional evaluation of processed calabash (*Lagenaria vulgaris*) seed meal as fish feeds ingredient

MATERIALS AND METHODS

Study area

The study was carried – out at the Fish Hatchery and Agriculture Chemical Laboratory of the Faculty of Agriculture, Usmanu Danfodiyo University Sokoto, Nigeria.

Collection of Calabash Seeds

Calabash seeds (*Lagenaria vulgaris*) were bought from Gayari, in Gummi Local Government Area of Zamfara State, and were brought to Botanical Laboratory, Department of Biological Sciences Usmanu Danfodiyo University, Sokoto for proper identification, in which were processed and formed into cake.

Processing Methods

Boiling

One kg of calabash seed samples were boiled with tap water in seed to water ratio 1kg: 10 litres in a 20 litre metal cooking pot for a duration of 30 minutes as described in (Vadivel and Pugalioti, 2007).

Toasting

One kg of calabash seeds were placed in a hot oven pan which were pre-heated on fire for 5 minutes to ensure that sufficient and uniform heat is obtained for toasting (Eyo, 2001).

Soaking

One kg of calabash seed samples were soaked in a bowl and cover containing tap water for 12 to 24hrs at room temperature in a seed and water ratio 1kg: 10litres as reported by (Vadivel and Pugalioti, 2007).

Drying

One kg of the calabash seeds were dried using an electric dryer (Tray Dryer 12 Trays) to a moisture content of 10%. This was achieved by drying at a temperature of 49⁰ C for 4 hours (Achinewu, 1982)

Raw

The raw seeds were not processed.

Oil extraction and preparation of cake

The seed oil was extracted using a mini-oil screw press extraction machine, Prasa DO, Model DL- 2YJ02, with a capacity of 10kg per hour. The procedures were as described in (Herz, 1997).

Assay: Sample of Calabash Seeds was used for proximate analysis and minerals according to the procedure of AOAC (AOAC, 2000).

Data analysis

Data obtained were subjected to analysis of variance (ANOVA) and, the treatment means were separated for significant differences following the procedure of Duncan's Multiple Range Test (Steel and Torrie, 1980). All the analyses were carried out using the computer software Statistical Package for the Social Sciences Version 2.0.

RESULTS AND DISCUSSION

The results of the study were presented in Tables 1, 2 and 3. Table 1 shows proximate composition of different processing methods for calabash seed cake before oil extraction. The highest moisture content was recorded in raw (12.50 ± 1.73) which was significant ($P > 0.05$) difference from the remaining processed seeds (boiled, dried, soaked and toasted). Similar values were reported in Mamman *et al.*, 2012, Jibrin *et al.*, 2018 and Chinyere *et al.*, 2009. Higher moisture content in raw un processed seeds could have been attributed to non-exposure of seeds to any processing method. Higher ash content was reported in Dried (11.50 ± 0.50) method which differed significantly to other processing methods, similarly the values were higher than those reported in (Eunice, 2018; Akpanbanje *et al.*, 2008; Alfewaz, 2004). Toasted processing methods recorded the greater lipid contents ($36.80 \pm 1.41\%$) with significant ($P < 0.05$) difference from other processing methods. Similar and higher lipid content was reported in Mamman *et al.* (2012). Presence of higher lipid content in toasted oilseed could have been the effects of heat on the cell content of the seeds thus allows the much content in the whole seeds. Higher Crude Protein content was observed also in toasted processed seeds, with no significant difference from other processing methods. The values were similar to those reported in Jibrin *et al.*, 2018 on boiled and toasted calabash seed. The fibre contents follow the same trend. However there was no clear trend on NFE contents of the processed and raw seeds in the present study.

The proximate compositions of calabash seed cake after oil extraction were presented in table 2. Boiled processing method recorded the highest moisture contents ($10.00 \pm 2.64\%$) the lowest was in toasted ($8.50 \pm 0.10\%$) with no significant differences ($P > 0.05$) from other processing methods, similar trends were reported in (Jibrin *et al.*, 2018) and (Mamman *et al.*, 2012). The least and highest moisture contents exhibited in these methods could have been attributed to the nature of these methods. The lipids content follows the same trend. Soaked processing method recorded the highest ash ($21.50 \pm 1.73\%$) which did not differ significantly with boiled and raw methods (19.50 ± 1.00 , $20.50 \pm 1.73\%$). The values were higher than those reported in (Jibrin *et al.*, 2018) and (Mamman *et al.*, 2012). Boiled processing method recorded the highest ($37.71 \pm 1.00\%$) crude protein content followed by Dried ($37.10 \pm 2.00\%$) and differed ($P > 0.05$) significantly. The lowest value was reported in raw processing methods ($32.98 \pm 1.00\%$). The values were similar to those reported in Mamman *et al.* (2012) on semi toasted calabash seed cake. Higher fibre contents were recorded in boiled and raw processing methods with no significant difference; which corroborate with fibre range for monogastric animals (NRC, 1995). The NFE in the dried ($26.86 \pm 1.00\%$) was higher than toasted ($25.45 \pm 0.95\%$) with no significant difference.

The minerals compositions of calabash seed cake after oil extraction were shown in Table 3. Raw oil extracted calabash seed cake in the present study contained high amount of analysed minerals (Na, 0.4 ± 0.29 mg/100g, K, 0.39 ± 0.04 mg/100g, Ca, 0.39 ± 0.02 , P, 70.67 ± 0.38 mg/100g, and Fe, 70.67 ± 0.38 mg/100g) with the exemption of Mg with significant ($P > 0.05$) difference. Higher minerals content in raw unprocessed cake could be due to lost of minerals as a result of processing methods employed which agreed with thereported of Jibrin *et al.* (2014).

Table 1: Proximate composition of processed calabash (*Lagenaria vulgaris*) seeds before oil extraction

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Treatments	Composition%					
	Moisture	Ash	Crude Lipid	Crude Protein	Crude Fibre	NFE
Toasted	10.00±1.00 ^c	10.50±1.00 ^{ab}	36.80±1.41 ^a	26.60±1.00	2.70±0.90	14.86±0.95 ^b
Dried	10.50±0.50 ^{bc}	11.50±0.50 ^a	34.20±0.91 ^{ab}	25.53±2.58	1.80±1.00	20.50±2.00 ^a
Boiled	12.00±0.86 ^{ab}	10.00±2.64 ^{ab}	30.66±3.78 ^b	25.00±1.00	3.03±1.00	17.90±1.00 ^{ab}
Soaked	11.00±0.50 ^{abc}	10.30±1.02 ^{ab}	30.00±1.00 ^b	25.11±1.13	3.20±1.20	20.68±1.01 ^a
Raw	12.50±1.73 ^a	8.50±0.10 ^b	30.40±2.00 ^b	25.50±2.64	2.10±0.10	21.00±2.64 ^a

Values with same letters are not significantly (P<0.05) different

Table 2: Proximate composition of processed calabash *Lagenaria vulgaris*) seed cake after oil extraction

Treatments	Composition%					
	Moisture	Ash	Crude Lipid	Crude Protein	Crude Fibre	NFE
Toasted	8.50±0.10	15.50±0.50 ^b	11.16±0.57	35.09±0.99 ^{abc}	1.50±0.10 ^b	25.43±0.95 ^a
Dried	9.00±1.00	10.50±0.50 ^c	12.33±1.25	37.10±2.00 ^{ab}	1.50±0.10 ^b	26.86±1.00 ^a
Boiled	10.00±2.64	19.50±1.00 ^a	12.50±1.73	37.71±1.00 ^a	3.00±0.50 ^a	17.29±1730 ^{ab}
Soaked	9.16±1.00	21.50±1.73 ^a	13.51±1.00	34.39±2.00 ^{bc}	1.00±0.50 ^b	22.65±0.65 ^b
Raw	9.50±1.00	20.50±1.73 ^a	12.70±1.81	32.98±1.00 ^c	3.00±0.50 ^a	19.11±1.00 ^c

Values with same letters are not significantly (P<0.05) different

Table 3: Mineralscomposition of processed calabash *Lagenaria vulgaris*) seed cake after oil extraction

Treatments	Composition (mg/100g)					
	Na	K	Ca	Mg	P	Fe
Toasted	0.23±0.05 ^d	0.54±0.01 ^d	0.22±0.00 ^d	0.14±0.00 ^c	28.00±20.19 ^d	28.00±2.79 ^c
Dried	0.26±0.01 ^b	0.66±0.04 ^c	0.26±0.00 ^c	0.24±0.00 ^b	47.42±2.77 ^c	47.42±2.77 ^b
Boiled	0.37±0.03 ^b	0.36±0.01 ^b	0.37±0.09 ^{ab}	0.29±0.00 ^a	71.29±1.48 ^b	71.29±1.48 ^a
Soaked	0.38±0.01 ^b	0.38±0.22 ^b	0.36±0.00 ^b	0.23±0.00 ^b	64.56±0.70 ^b	64.56±0.79 ^a
Raw	0.4±0.29 ^a	0.39±0.04 ^a	0.39±0.02 ^a	0.27±0.06 ^b	70.67±0.38 ^a	70.67±0.38 ^a

Values with same letters are not significantly (P<0.05) different

CONCLUSION AND RECOMMENDATION

In conclusion, there was a clear trend that the oil extracted samples of the processed seed cake showed appreciable required dietary nutrients which more or less made partial or complete substitute for most plant based conventional feed ingredients in aquaculture. The study revealed that processed oil extracted calabash

seed cake reported are rich source of nutrients that can be recommended to substitute plant based conventional feed ingredients in feeding fish.

The study therefore recommended that further investigation on biological assay through feeding trials to assessed growth and nutrients utilization, haematology, digestibility, and some chemical investigation such ant nutrients, fatty and amino acids profiles should be carried out to add to the potential of these diets in cultured fish.

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PROXIMATE COMPOSITION OF ACHEE APPLE (*Blighia sapida*) LEAVES, SEEDS AND ITS PODS MEALS AS FISH FEEDSTUFFS

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ABSTRACT

In this present study, matured ackee apple leaves, seeds and pods samples were collected from Ackee tree at Kainji Medical Centre premises, New Bussa, Niger State, Nigeria and analyzed for chemical composition before inclusion in fish feed to know their nutritive value. Mean moisture content, crude protein, crude lipid, crude fibre, ash and carbohydrate content of the leaf-meal on dry matter basis were found to be 7.94 ± 0.03 , 15.10 ± 0.02 , 2.59 ± 0.02 , 11.44 ± 0.01 , 11.03 ± 0.04 and 51.92 ± 0.04 % respectively. Mean moisture content, crude protein, crude lipid, crude fibre, ash and carbohydrate content of the seed-meal were found to be 8.11 ± 0.01 , 14.75 ± 0.01 , 10.78 ± 0.01 , 30.82 ± 0.01 , 4.68 ± 0.16 , 4.68 ± 0.16 and 30.77 ± 0.06 % respectively while the mean moisture content, crude protein, crude lipid, crude fibre, ash and carbohydrate content of the pod-meal were found to be 7.91 ± 0.01 , 10.78 ± 0.02 , 0.76 ± 0.02 , 17.85 ± 0.02 , 12.10 ± 0.02 and 50.59 ± 0.06 % respectively. The study concluded that ackee apple leaves, seeds and pod meals could find applications as useful ingredient in fish feed ingredients as an energy supplement.

KEYWORDS: Ackee apple leaf, seed, pod meals, Proximate composition

INTRODUCTION

Until now, the bulk of the non-conventional feed resources (NCFR) as the most viable and economic sources of feedstuff for fish feed manufacture in Nigeria are sourced from plant resources such as aquatic or terrestrial macrophytes. Meanwhile, a wide range of tree plants containing fruits that are rich in proteins exist in the forest of many African countries which are underutilized (Madu *et al.*, 2003; Ezeagwu *et al.*, 2004). The under-utilization of some of these protein tree bearing fruits is due to inadequate information on their nutritional benefits. One of such plant resources is Ackee, *Blighia sapida*. Ackee, scientifically called *Blighia sapida* and locally called *Isin* are of the family Sapindaceae (Goldson, 2005; Mitchell *et al.*, 2008; Lancashire, 2013). The Ackee apple is widely known for the edible part of its fruit called arils. The origin of the fruit has been traced to Jamaica (JIS, 2018) where the edible part (arils) forms part of their national dish (Oyeleke *et al.*, 2014).

The ackee plant produces fruits twice a year within the months of January to March and June to August in Jamaica (Lancashire, 2013). The average height of the typical ackee plant ranges from 7 to 25 m tall and the tree is usually highly branched (Mitchell *et al.*, 2008; JIS, 2018). The leaves of the plant are alternate and pinnately compound with three to five pairs of elliptical leaflets which are 6 to 18 cm long and 5 to 7 cm wide (Dutta, 1999; Dossou, 2014). The inflorescence is usually 3 to 7 inches long and may be described as racemose or having clusters of greenish-white fragrant flowers (Dossou, 2014). These small flowers are usually male or bisexual and insect pollinated (Dutta, 1999; Dossou, 2014). The Ackee apple tree is an evergreen tree, mostly used for health benefits such as membrane development, control cholesterol level, dietary fibre maintain digestive health, epilepsy and other nervous problems, healthy skin preventing birth

defects, bone and teeth health; ackee helps in curing conditions like fever, colds and edema and also for many folk-medicinal benefits(Kriti, 2019).

Repeated doses of aqueous seed extract have been used to eliminate parasites. Also, ackee pod poultice has been used to treat skin infections, ringworm and liver spots. The ripe arils of ackee along with sugar and cinnamon have been used to treat fever and dysentery. The ackee tree bark mixed with certain spices can relieve pain. The new leaves are crushed and applied to the forehead to ease a severe headache; when mixed with salt, it is applied on ulcers. Ackee leaf tea can also be used to alleviate cold (Kriti, 2019). This study, therefore, aims to examine the proximate composition of Ackee apple (*Blighia sapida*) leaves, seeds and its pods meals as fish feedstuffs.

MATERIALS AND METHODS

Collection and processing of Ackee Apple (*Blighia sapida*) leaves, seeds and its pods

Ackee Apple samples were obtained from Ackee tree within Kainji Medical Centre premises, New Bussa, Niger State, Nigeria. The collected samples were sun-dried and ground into fine powder using domestic grinding machine and analyzed for proximate composition according to standard method. The sundried samples were taken to the Laboratory of JaaGee Nigeria Limited, Ibadan, Oyo State for proximate composition analysis of moisture content, crude protein, crude lipid, crude fibre, ash and carbohydrate.



I: Ackee Apple (*Blighia sapida*) leaves

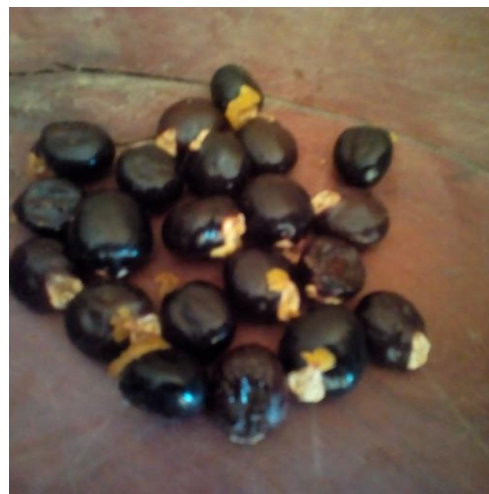


Plate II: Ackee Apple (*Blighia sapida*) seeds



Plate III: Ackee Apple (*Blighia sapida*) pods

Method of Proximate Analysis

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These analyses show the moisture content, crude protein content, crude lipids, ash content, crude fibre and carbohydrate content of the samples.

Moisture content

Moisture content of Ackee apple meals were determined by drying the leaves seeds and its pods (in triplicate) in a Gallenkamp oven at 105°C until constant weight was attained (AOAC, 2010).

The percentage of the moisture content in the sample was calculated by the following formulae:

$$\% \text{ of moisture} = \frac{\text{Weight of original sample} - \text{weight of dried sample}}{\text{Weight of original sample}} \times 100$$

Weight of original sample

Crude protein content

Crude protein content was calculated by multiplying the values obtained from Kjeldahl's nitrogen by a protein conversion factor of (N x 6.25) a factor recommended for animal origin (Bernice and Merrill, 1975).

Crude lipid

Crude lipid was quantified by the method described by (AOAC, 2010) using the solvent apparatus and n-hexane as a solvent. Calculation: % of crude lipid = (corrected weight of fat ÷ weight of sample) x 100.

Ash content

Ash content of each samples were estimated by following incineration method (Maynard, 1970) using dry ashing in Lenton muffle furnace at 550°C for 24hours. Calculation: % of ash = (weight of ash ÷ weight of sample) × 100

Crude fibre

Crude fibre was estimated by acid-based digestion with 1.25% H₂SO₄ (w/v) and 1.25% NaOH (w/v) solutions (AOAC, 2010).

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, 2010). Calculation: % of carbohydrate = 100 – (moisture + ash + protein + fat).

Gross Energy

The sample calorific value was estimated (in kcal) according to AOAC, (2010). Gross energy = Caloric value of protein 5.65, NFE 4.1 and lipid 9.45kcal/g (NRC, 1993).

Data Analysis

All data obtained from the experiment were analyzed using Statistical Package for Social Science (SPSS) Version 20.0. One-way Analysis of Variances (One-way ANOVA) was used to compare the means of values for significant differences at P<0.05, followed by Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

The proximate composition of Ackee Apple (*Blighia sapida*) leaf meal is presented in Table 1. Results of the proximate contents of the leaf meal showed that *Blighia sapida* leaf meal contained 92.06% dry mater, 15.10% crude protein, 2.59% crude lipid, 11.44% crude fibre, 11.03% ash, and 51.92% carbohydrate. The proximate composition of Ackee Apple (*Blighiasapida*)seed meal is presented in Table 2. Results of the proximate contents of the seed meal revealed that *Blighiasapida* seed meal contained 91.89% dry mater, 14.75% crude protein, 10.78% crude lipid, 30.82% crude fibre, 4.78% ash, and 30.77% carbohydrate. The proximate composition of Ackee Apple (*Blighia sapida*) pod meal is presented in Table 3. Results of the proximate contents of the pod meal showed that *Blighia sapida* pod meal contained 92.09% dry mater, 10.78% crude protein, 0.76% crude lipid, 17.85% crude fibre, 12.10% ash, and 50.59% carbohydrate.

The proximate composition of fish feedstuff samples showed the level of some available essential nutrients in these feedstuff products. The ash content and protein content of food are indications of the level of mineral elements and amino acid content respectively in these feedstuff samples. These compositions were evaluated on the meals of ackee apple leaves, seeds and pods using established procedures. The moisture content of the ackee apple leaves, seeds and pods meals are shown in Table 4. Results showed that ackee apple seed meal had higher moisture content than the ackee apple leaf and ackee apple pod meals. The ash content which is a measure of the level of minerals in the samples was also found to be higher in ackee apple pod meal than ackee apple leaf and seed meals respectively. The crude fibre content of the samples was found to be significantly higher in ackee apple seed meal than the pods and leaf meals. Sample ackee apple seed meal was also found to contain higher fat content than ackee apple leaf meal while the protein content of ackee apple seed meal was significantly higher than that of the ackee apple leaf and pod meals. The values obtained for crude protein content, crude lipid content and carbohydrate obtained in this study were slightly different for wild biscuit leaf meal and wild biscuit seed meal by Alatisie *et al.* (2021) but lower than those reported by Oyeleke *et al.* (2014).

CONCLUSION

This study has shown that ackee apple being an under-utilized plant has useful nutrients comparable with other known plant protein sources. The leaf-meal of the ackee apple has been shown to display better useful nutrients than the seed-meal and pod-meal. However, the ackee apple leaf, seed and the pod meals have potential to be used as fish feed ingredients supplying good energy to cultureable fish species.

Table 1: Proximate composition of Ackee Apple (*Blighia sapida*) leaf meal (% dry weight)

Parameters	Sample 1	Sample 2	Sample 3	Mean±SD
Moisture content (%)	7.93	7.97	7.92	7.94±0.03
Crude protein (%)	15.11	15.08	15.12	15.10±0.02
Crude lipid (%)	2.57	2.60	2.59	2.59±0.02
Crude fibre (%)	11.43	11.45	11.44	11.44±0.01
Ash (%)	11.06	10.98	11.05	11.03±0.04
CHO (%)	51.96	51.92	51.88	51.92±0.04

Table 2: Proximate composition of Ackee Apple (*Blighia sapida*) seed meal (% dry weight)

Parameters	Sample 1	Sample 2	Sample 3	Mean±SD
Moisture content (%)	8.10	8.12	8.10	8.11±0.01
Crude protein (%)	14.74	14.76	14.74	14.75±0.01
Crude lipid (%)	10.77	10.79	10.77	10.78±0.01
Crude fibre (%)	30.81	30.83	30.82	30.82±0.01
Ash (%)	4.77	4.79	4.77	4.68±0.16
CHO (%)	30.81	30.71	30.80	30.77±0.06

Table 3: Proximate composition of Ackee Apple (*Blighia sapida*) pod meal (% dry weight)

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Parameters	Sample 1	Sample 2	Sample 3	Mean±SD
Moisture content (%)	7.90	7.92	7.90	7.91±0.01
Crude protein (%)	10.76	10.78	10.80	10.78±0.02
Crude lipid (%)	0.75	0.78	0.76	0.76±0.02
Crude fibre (%)	17.84	17.86	17.86	17.85±0.02
Ash (%)	12.09	12.10	12.12	12.10±0.02
CHO (%)	50.66	50.56	50.56	50.59±0.06

Table 4: Proximate composition of the leaf, seed and pod meals of Ackee Apple (*Blighia sapida*)

Parameters	Ackee Apple leaf meal	Ackee Apple seed meal	Ackee Apple pod meal
Moisture content (%)	7.94±0.03 ^b	8.11±0.01 ^a	7.91±0.01 ^b
Crude protein (%)	15.10±0.02 ^a	14.75±0.01 ^b	10.78±0.02 ^c
Crude lipid (%)	2.59±0.02 ^b	10.78±0.01 ^a	0.76±0.02 ^c
Crude fibre (%)	11.44±0.01 ^c	30.82±0.01 ^a	17.85±0.02 ^b
Ash (%)	11.03±0.04 ^b	4.68±0.16 ^c	12.10±0.02 ^a
CHO (%)	51.92±0.04 ^a	30.77±0.06 ^c	50.59±0.06 ^b
Gross energy (kcal/100g)	322.67 ^a	311.57 ^b	275.51 ^c
Metabolizable energy(kcal/100g)	291.39 ^a	156.02 ^c	252.32 ^b

Mean values in the same row with different superscripts are significantly different ($p < 0.05$)

* Nitrogen free extract (Calculated by difference) = 100 – (moisture + protein + ash + fat + fibre)

*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

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3

GROWTH RESPONSE AND NUTRIENTS UTILISATION OF *HETEROBRANCHUS BIDORSALIS* (GEOFFROY ST. HILAIRE 1809) FED GRADED LEVELS OF FERMENTED *CASSIA FISTULA* SEED MEAL DIETS

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ABSTRACT

Feeding trial was carried out for 90 days to evaluate the effect of fermented *Cassia fistula* seed meal as a plant protein source in the diet of *Heterobranchus bidorsalis*. 40% isonitrogenous diets was formulated and fermented *Cassia fistula* was included at 0%, 25%, 50%, 75% and 100%. *Heterobranchus bidorsalis* fingerlings of mean weight of 1.21g and mean length of 4.0cm were stocked at the rate of 10 fish per 35L capacity plastic bowl with semi-flow system. The experiment was conducted at the Department of Fisheries, University of Maiduguri. They were fed at 5% body weight for 90 days. Highest mean weight gain of 17.56g was recorded in control and lowest of 7.42g in fish fed 100% FCF diet. While, specific growth rate of 3.01 in fish fed control diet and lowest of 1.50 in 100% FCF diet. Relative growth rate ranged from 285.57 – 1399.75%. Feed conversion ratio of 1.21 in fish fed control and 1.79 in 100% FCF diet. Most of the growth parameters recorded no significance difference ($P > 0.05$) among control, 25% and 50% FCF diets. The results revealed that inclusion level of 25% FCF seed meal is recommended for growth and nutrients utilization of *Heterobranchus bidorsalis*.

INTRODUCTION

The major challenge facing aquaculture nutritionists is the development of cost effective feeds using locally available, cheap and unconventional resources. Non-animal proteins derived from legume and/or oil seeds or cereal gluten are now introduced in fish diets (Médale *et al.*, 2013), but plant sources have limitations, such as palatability issues, presence of anti-nutritional substances, low concentrations of sulfur amino acids, and high proportions of fiber and non-starch polysaccharides (Sanchez-Muros *et al.*, 2014). Expensive feeds marginalizes or even nullify the profitability of fish farming production, consequently lowering yield in terms of quantity. Fish feed account for at least 60% of the total cost of production hence has motivated research into locally available, cheap and unconventional feeds as alternative feed stuffs for fish (Tiamiyu *et al.*, 2013) to reduce cost of production without compromising the health of the fish.

Jamu and Ayinla (2003) reported that the low quality of fish feed and its attendant high cost are the major factor limiting the development of aquaculture sector in Africa and therefore, research in fish nutrition that will utilize locally available ingredients without reducing the quality of the feed is urgent and crucial to the overall success of aquaculture development, growth and expansion in Nigeria and the continent. Soybeans (*Glycine max*), however, is very expensive due to human consumption needs and its use in other animal feeds. It has therefore become vital to search for alternative that are not in direct competition with human and other animals, hence an evaluation into the effect of dietary inclusion of processed *Cassia fistula* seed meal on growth performance and nutrient utilization of *Heterobranchus bidorsalis* becomes imperative. According to Akinyede and Amoo, (2009) *Cassia fistula* is a moderate sized deciduous tree 10 m tall, flowers yellow, leaves alternate, pinnate 30-40 cm long, with 4-8 pairs of ovate leaflets, 7.5-15 cm long, 2-5 cm broad. Fruits are pendulous, cylindrical brown, septate is 25-50 cm long, 1.5-3 cm in diameter, with 25-100 seeds. Seeds lenticular, light brown lustrous. The common name of *Cassia fistula* is called

golden flower and locally called malga in hausa. The proximate composition of *Cassia fistula* seed meals are and protein ($27.60 \pm 0.11\%$), fat ($6.73 \pm 0.10\%$) and ash ($4.61 \pm 0.02\%$) The protein contents of *Cassia fistula* seed can be considered for use in food and feed formulations.

MATERIALS AND METHODS

A completely randomized design was used, where one hundred and fifty fingerlings was randomly allocated to five dietary inclusion levels of 0%, 25%, 50%, 75% and 100% fermented *Cassia fistula* (FCF). Ten fingerlings of *Heterobranchus bidorsalis* per 35L capacity bowl and were replicated. A semi-flow through system comprising of wooden platform, PVC pipes and 35L capacity plastic bowls was designed and constructed (Micheal, *et al.*, 2015). The plastic bowls were filled with water up to three quarter. Continuous aeration and renewal of the water every morning was maintained to avoid problem of oxygen depletion, pollution from excreta and other waste products. Water quality was monitored every bi-weekly throughout the feeding trial using the method described by Fakunle *et al.* (2013). Temperature ($^{\circ}\text{C}$) and pH were measured by PEN pH meter; while dissolved oxygen meter (JBP 607) was used for dissolved oxygen in milligram per litre (mg/l) and ammonia were measured. The experiment was conducted for 90 days.

The feed ingredients used includes; Fish meal, Glycine max, Yellow maize, Premix, Lysine, Methionine, Vegetable oil, Salt, Vitamin C and Chromium III oxide as a marker. They were purchased in Maiduguri Monday Market and were processed, ground into meals following the methods described by Tiamiyu *et al.* (2014). *Cassia fistula* were gotten within University of Maiduguri campus. The seeds were moistened, kept in a white plastic bucket with cover and put in the laboratory cupboard for three days in a darkened environment needed for solid fermentation as described by Sogbesan *et al* (2017)

Five different groups of feed were formulated at 40% crude protein using Pearson square method (Table 1). The diets were mixed thoroughly and pelletized using a pelleting machine, dried and packaged in an air-tied bags. The Fish were fed twice daily at 5% body weight throughout the periods under monitored water quality (Table 2). Proximate compositions of experimental diets, faecal samples and Fish before and after experiment were determined according to the method describe by AOAC (2000). Data obtained were subjected to analysis of variance (ANOVA) at 5% level of significance and means were separated using Duncan multiple range test.

Table 1: Percentage Compositions of Ingredients with Fermented *Cassia fistula* Seed Meal

Ingredients (%)	Level of soya bean meal replaced by FCF (%)				
	0	25	50	75	100
Fish Meal (62%)	35.38	35.38	35.38	35.38	35.38
Soya Bean Meal (44%)	35.38	29.42	22.13	11.00	0.00
FCF (30.6%)	0.00	9.90	22.12	33.09	58.42
Yellow Maize (10%)	24.69	21.29	16.26	16.27	1.99
Premix	1.00	1.00	1.00	1.00	1.00
Lysine	0.40	0.40	0.40	0.40	0.40
Methionine	0.40	0.40	0.40	0.40	0.40
Salt (NaCl)	0.50	0.50	0.50	0.50	0.50
Vitamin C	0.20	0.20	0.20	0.20	0.20
Vegetable Oil	1.00	1.00	1.00	1.00	1.00
Starch	0.50	0.50	0.50	0.50	0.50
Dicalciumphosphate	0.50	0.50	0.50	0.50	0.50
Chromium III oxide	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.0	100.0	100.00

*The premix manufactured by DSM Nutritional products Europe Limited, Basle, Switzerland supplied the following per Kg: Vitamin A (5,000,000 I.U), Vitamin E (16000 mg), Vitamin K₃ (800 mg), Vitamin B₁

(1200 mg), Vitamin B₂ (22000 mg), Niacin (2200 mg), calcium pantothenate (4600 mg), Vitamin B₆ (200 mg), Vitamin B₁₂ (100 mg), Folic acid (400 mg), Biotin (32 mg), Chlorine chloride (200000 mg), Manganese (948000 mg), iron (40000 mg), Zinc (3200 mg), Copper (3400 mg), iodine (600 mg), cobalt (120 mg), selenium (48 mg), anti-Oxidant (4800 mg).

RESULTS and DISCUSSION

Growth performance and nutrient utilization of *Heterobranchus bidorsalis* fed graded levels of fermented *Cassia fistula* (FCF) is recorded in table 2. The mean weight gain (MWG) ranged from 7.41g/fish to 17.56g/fish. There are no significant differences ($p>0.05$) in MWG among control, 25% FCF and 50% FCF but are significantly different from fish fed 75% FCF and 100% FCF. The result is lower than 22.60g - 26.21g recorded in *Clarias gariepinus* by Sogbesan *et al* (2017) and higher than 2.5g – 7.73g in *Clarias gariepinus* as documented by Micheal (2015). The difference in the results from what was obtainable in other studies could be differences in species. Feed conversion ratio recorded the highest value (1.79) in fish fed 100% FCF and the lowest of 1.21 in control. There were significant differences ($P<0.05$) in FCR among the treatments. Increase in feed conversion ratio was observed at higher inclusion level of *Cassia fistula*, a similar observation was also documented by Jimoh *et al*, (2013) in related study. Protein efficiency ratio (PER) ranged from 0.15 to 0.33. No significant differences ($P>0.05$) existed in PER among control, 25% and 50% FCF. Desilva and Adenson (1995) reported that protein efficiency ratio is a measurement of how well the protein sources in a diet could provide the essential amino acid requirement of fish fed. The K_1 shows no significant differences ($p>0.001$) among the treatments groups. While K_2 values ranged from 1.29 to 1.81 with the lowest of 1.29 in fish fed 100% FCF diet. The well-being of *Heterobranchus bidorsalis* assessed by condition factor values above 1.0 and is in agreement with the report of Sogbesan (2007).

This result was in agreement with Sogbesan *et al*. (2005) and Sogbesan and Ugwumba (2006) who state that combination of protein sources is better than single protein sources in the diet of fish. Similarly, the better performance of fish at 25% *Cassia fistula* agrees with the report of Oso *et al*. (2011); Anene *et al*. (2012); Tihamiyu *et al*. (2014); Hassan *et al*. (2015); Oyegbile *et al*. (2017) and Afe *et al*. (2019). But disagree with Bake *et al*. (2015) who reported better growth performance in fish fed 20% fermented *Senna obtusifolia* and 100% of *Phaseolus linatus* diet fed *Heterobranchus bidorsalis* (Aliu and Odeh, 2019). The better performance at 25% might have raised from physiological mechanism in *Heterobranchus bidorsalis* to compensate for presence of low amount of anti-nutrients at 25% inclusion. There is poor growth performance at higher inclusion (50%, 75% and 100%) of *Cassia fistula*. The poor growth performance of *Heterobranchus bidorsalis* fed 50%, 75% and 100% *Cassia fistula* diets may be attributed to inadequate protein utilization due to residual concentration of other anti-nutrients such as alkaloids, phenols, tannin and saponins (Bressani, 1994; Francis *et al*. 2001; Adeniji *et al*., 2007). Also, *Heterobranchus bidorsalis* was unable to effectively utilize high dietary inclusion levels beyond 25% due to low concentration of cellulase in omnivorous fishes, but absent in carnivorous and high in herbivorous (Fagbrenro *et al*., 2005). Adikwu (2003) reported that the lower the feed conversion the better feed utilization. Similar results were also observed by Shabir *et al*. (2003) and Jabeen *et al* (2004) in related studies. A high survival rate was observed in control 25% and 50% *Cassia fistula*, while lower were recorded in 75% and 100%. This may be due to presence of residual anti-nutrient which agree with Alegbeleye (2005). Similar observation was also made by Aliu and Odeh (2019); Afe *et al*. (2019) in *Heterobranchus bidorsalis* fed unconventional feeds. The mean water quality parameters measured during the experimental feeding of *H. bidorsalis* with differently processed test plant meals based diets indicated that the parameters were within acceptable recommended ranges of optimum growth of fish.

CONCLUSION

The outcome of this study indicated that inclusion of processed *Cassia fistula* seed meals can be used to replace Glycine max partially as plant source protein in the diet of *Heterobranchus bidorsalis*. It means

therefore that *Heterobranchus bidorsalis* can be fed with fermented seed meals of *cassia fistula* at 25% inclusion level.

Table 2 :Growth indices and survival rate of *Heterobranchus bidorsalis* fingerlings fed fermented *Cassia fistula* diets for 90 days

Parameter	Inclusion Levels of fermented <i>Cassia fistula</i> seed meals (%)					
	0	25	50	75	100	SEM
TIW (g)	12.07	12.06	12.06	12.06	12.06	0.27 ^{ns}
TFW (g)	181.02 ^a	180.87 ^a	160.68 ^b	89.22 ^c	46.50 ^d	7.342
MIW (g/Fish)	1.210	1.206	1.206	1.206	1.203	4.21 ^{ns}
MFW(g/Fish)	18.77 ^a	18.09 ^a	16.51 ^a	11.02 ^b	8.61 ^b	1.61
MWG(g/Fish/)	17.56 ^a	16.88 ^a	15.30 ^a	9.81 ^b	7.41 ^b	1.61
BWWG(g/F/wk)	1.46 ^a	1.41 ^a	1.28 ^a	0.82 ^b	0.62 ^b	0.13
MIL (cm)	4.03	4.0	4.0	3.98	3.97	0.071 ^{ns}
MFL (cm)	10.23 ^a	0.23 ^a	9.70 ^b	9.43 ^c	8.73 ^d	0.311
RGR (%)	1399.75 ^a	1399.75 ^a	1232.34 ^a	639.80 ^b	285.57 ^b	2.10
SGR (g/day)	3.01 ^a	3.01 ^a	2.88 ^a	2.22 ^b	1.50 ^c	0.08
K ₁	1.86	1.90	1.93	1.93	1.90	0.07 ^{ns}
K ₂	1.75 ^a	1.69 ^a	1.81 ^a	1.31 ^b	1.29 ^b	0.05
FCR	1.21 ^e	1.32 ^d	1.44 ^c	1.57 ^b	1.79 ^a	0.02
PER	0.28 ^{ab}	0.30 ^{ab}	0.33 ^{ab}	0.26 ^b	0.15 ^c	0.02
Survival (%)	90.00 ^a	90.00 ^a	90.00 ^a	70.00 ^b	40.00 ^c	6.32

Keys

MIW =Mean initial weight

MFW =Mean final weight

MWG =Mean weight Gain

Bi-WWG = Bi-weekly weight Gain

MIL = Mean Initial length

MFL = Mean Final Length

RGR = Relative Growth Rate

SGR = Specific Growth Rate

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4

COMPARATIVE ANALYSIS ON THE NUTRITIONAL COMPOSITION OF *CLARIAS GARIEPINUS* FROM A LENTIC AND LOTIC FRESHWATER ECOSYSTEM IN EDO STATE, NIGERIA

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ABSTRACT

Water quality has been considered a major factor in fish meat quality. The objective of the study was to determine the effects of different water quality sources on the nutrient composition of *Clarias gariepinus* from Ikpoba Reservoir and Owan River. Physico-chemical parameters of water samples, proximate and mineral contents of the fish collected from both locations from February 2018 to January 2019 were determined as outlined by standard methods. Results showed that the Ikpoba Reservoir is highly polluted with low dissolved oxygen content and high nitrate, phosphate, iron, zinc and copper contents; while the pollution level is low in Owan River. The moisture, protein, lipid, ash and mineral contents in *Clarias gariepinus* were significantly ($p < 0.01$) influenced by the prevailing water conditions of the study locations. *Clarias gariepinus* obtained from Owan River had moisture (68%), protein (16.52%) and lipid (7.18%) contents that were significantly higher than the moisture (61%), protein (15.15%) and lipid (6.03%) contents in *Clarias gariepinus* from Ikpoba Reservoir. Protein and lipid contents showed positive correlation with water dissolved oxygen content. *Clarias gariepinus* obtained from Ikpoba Reservoir has significantly higher contents of ash, iron, zinc, calcium, sodium and copper in comparison to fishes from Owan River. This study has broadened the knowledge on effect of water quality on the nutritional composition of fish meat, thereby assisting in determining the suitability of different aquatic ecosystems for the production of quality fish meat.

KEYWORDS: Ikpoba reservoir, Nutritional Composition, Owan River, Water Quality.

INTRODUCTION

Fishes are one of the important and cheapest source of animal protein and essential nutrients needed in human and animals' diets (Sadiku and Oladimeji, 1991; Adeniyi *et al.*, 2012). Its abundance, palatability and wide acceptance among consumers confers an advantage on fish meat over other animal sources (Holma and Maaleku, 2013). The quality of water is considered the main factor in fish quality, which affects the fish normal health and reproductive performance (Balogun, 2015). The nutritional composition of fish muscle have been reported to be influenced by exogenous factors such as water quality, seasonality and feed availability for the fish (Varljen *et al.*, 2003; Fanuel *et al.*, 2017). The nutritional composition of freshwater fishes have been found to differ between geographical localities (Zenebe *et al.*, 1998), and throughout the year due to significant fluctuations and environmental changes in the aquatic habitat which affect their proximate and mineral composition (Olsson *et al.*, 2002). Although several nutrient composition studies have been carried out on various fish species from different aquatic habitats in Nigeria (Adewumi *et al.*, 2014; Enuneku and Adelusi, 2015; Job *et al.*, 2015; Olopade *et al.*, 2016; Egun and Oboh, 2022), there is paucity of research literature which have attempted to relate the nutritional quality of fish populations in different freshwater systems to the prevailing water quality.

Association analysis, using a selection of sites with very similar habitat but a wide range of water quality, would provide a useful approach to determining the quantitative relationships between fish nutritional status and water quality (Mainstone and Gulson, 1990). River systems are known to undergo self-purification because of their lotic nature, but this is different for reservoirs which are lentic, and are known to accumulate/concentrate pollutants which get into them. Therefore, the choice of Ikpoba Reservoir and Owan River as locations for this study in ascertaining the effects and suitability of the different ecosystems

in the production of nutritious fish meat. Also, *Clarias gariepinus* was selected for this study due to its consumer preference and commercial importance.

MATERIALS AND METHODS

Description of Study Locations

This study was carried out at the Ikpoba Reservoir (Latitudes 006°22'50" N and 006°22'43" N and Longitudes 05°38'36" E and 05°38'46" E) situated in Benin City and 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 Village Edo State. Ikpoba Reservoir was established in 1977 as a result of the impounding of Ikpoba River by a weir, which separates the downstream from the upstream sections of the river. The reservoir is about 3 km long and 0.6 km wide, and covers a total surface area of about 1.1 million m². It impounds 1.5 million m³ of water at full capacity (Akujieze, 2004). The Owan River transverses through several rural communities and serves as a source of commercially important fish species to the artisanal fishing households and the agrarian communities.

Collection of Water and Fish Samples.

Water and fish samples were collected monthly (February 2018 to January 2019) from both locations. The water was collected into duplicate sterile sample bottles, stored in ice chest, and transported to the laboratory for analysis. The fish samples were harvested with the assistance of artisanal fishermen and properly identified using taxonomic guide (Idodo-Umeh, 2003). The samples were packed in polyethylene bags and preserved in ice blocks before transported to the Benin Owena River Basin Authority/ University of Benin Analytical laboratory for analysis.

Sample Preparation

In the laboratory, the fish samples were thoroughly washed with distilled water to remove any adhering contaminants and drained under folds of filter paper. The fish samples were dissected and fish fillets were collected along the lateral line. All collected fillet samples were washed with distilled water, packed in polythene bags and stored in a deep freezer at 18 °C prior to analysis. For analysis, fillet samples were homogenised and subsamples of the homogenate were taken for respective analytical tests.

Analytical Methods.

Collected water samples were analyzed for physico-chemical parameters following appropriate quality assurance and quality control standard protocol (APHA 2012). Fish samples were subjected to proximate and mineral content analysis as described by AOAC (2010) and Reksten *et al.* (2020).

Data analysis or Statistical analysis

All statistical analysis were computed using Microsoft® Office Excel 2013 version and Statistical Package for Social Sciences (SPSS) version 21. Independent T- test ($p < 0.01$) was used to compare the means of the proximate composition of *C. gariepinus* from the two water bodies. Pearson's correlation analysis were used to determine relationship between proximate and mineral composition of fishes and water quality parameters. The data are presented as means $\pm$ SD per 100 g of the three composite fish samples and reported to the same units of expression.

RESULTS AND DISCUSSION

Water Quality: Table 1 shows the physico-chemical content of water from the two study locations. Owan River had higher pH and dissolved oxygen (DO) content; while water from Ikpoba Reservoir recorded higher amount of biochemical oxygen demand (BOD₅), nitrate, phosphate, iron, zinc and copper. The elevated levels of the physico-chemical parameters recorded in Ikpoba Reservoir is an indication that the lentic water body is highly polluted and exposed to high influx of pollutants from anthropogenic activities within the

reservoir watershed. The elevated dissolved oxygen content in Owan River is an indication that the river is subject to minimal pollution.

Nutritional Composition of Fish: Table 2 shows the inferential statistics of the proximate and mineral composition of *C. gariepinus* from the two water sources. The results for moisture content, protein, lipid, ash and mineral contents were significantly ($p < 0.01$) influenced by the prevailing water conditions. Fish samples obtained from Owan River had moisture, protein and lipid contents that was significantly higher than fish from Ikpoba Reservoir; while their ash content were significantly lower in comparison to fishes from Ikpoba Reservoir.

Protein content in fish is generally present in the range of 16 – 18% (Ninan, 2003). The mean protein content of *C. gariepinus* from Owan River (16.52%) indicate that it has an adequate protein content. However, the protein content of *C. gariepinus* from Ikpoba Reservoir (15.15%) was slightly below 16%, which implies that its protein content is inadequate. Fishes are classified based on their lipid content. The lipid content of *C. gariepinus* from Ikpoba Reservoir (6.03%) and Owan River (7.18%) classifies them as intermediate (2 – 8 % total fat), which implies that they are good sources of fish oils (European Food and Safety Authority, 2005). The low levels of pollutants and the lotic nature of Owan River relative to Ikpoba Reservoir could have impacted positively the moisture, protein, and lipid content of fish from Owan River. Significantly higher contents of ash, iron, zinc, calcium, sodium and copper were recorded in fishes from Ikpoba Reservoir when compared to fishes from Owan River. This could be attributed to the higher levels of these mineral elements in the water of Ikpoba Reservoir. According to Fanuel *et al.* (2017), the concentration of minerals in the harvest waters influences the content of those minerals in the habitat fish.

Association analysis using Pearson correlation was used to determine the relationships between the nutritional composition of *C. gariepinus* and water quality from both study locations (Tables 3 and 4). Protein content correlated positively with dissolved oxygen and negatively with phosphate, zinc and copper levels in water. Lipid content showed positive correlation with dissolved oxygen, and negative correlation with phosphate and iron levels in water. While ash content correlated positively with iron and copper; and negatively with dissolved oxygen. The mineral contents in *C. gariepinus* showed positive correlation with the minerals contents in the water bodies. In this study, the observed differences in the nutritional composition of fish from the two ecosystems can be attributed to their pollution status. The lentic nature of Ikpoba Reservoir and high level of pollution caused by municipal and industrial effluents from the surrounding urban centres, resulted in the decreased the concentration of dissolved oxygen and higher amounts of nitrates and phosphates in the water. While the self cleansing ability of the Owan River improved it water quality. Consequently the nutritional composition of *C. gariepinus* from the Ikpoba Reservoir was negatively affected.

Conclusion

This study has broadened the knowledge on the proximate and mineral composition of *Clarias gariepinus* under different aquatic ecological conditions. The effect of water quality on the nutritional composition of fish meat has been clearly demonstrated. *Clarias gariepinus* obtained from the Ikpoba Reservoir which is highly polluted had significantly inferior nutrient composition when compared to *C. gariepinus* obtained from Owan River. Information provided in this study will assist in the determination of the suitability of different aquatic ecosystems for the production of quality fish meat.

Table 1: Physico-chemical parameters from Ikpoba Reservoir and Owan River February 2018 to January 2019

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	pH	DO	BOD ₅	Nitrate	Phosphate	Iron	Zinc	Copper
Ikpoba Reservoir	5.87	4.57	4.17	16.23	3.85	0.90	1.47	1.28
Owan River	6.13	6.57	1.89	4.79	1.77	0.27	0.42	0.36

Table 2: Proximate and mineral content of *Clarias gariepinus* from Ikpoba Reservoir and Owan River February 2018 to January 2019.

Parameters	Ikpoba Reservoir			Owan River			p -Value
	Mean $\pm$ SD	Min.	Max.	Mean $\pm$ SD	Min.	Max.	
Moisture (%)	61.09 $\pm$ 3.81	54.73	66.31	68.00 $\pm$ 1.41	65.12	70.21	$p < 0.01$
Protein (%)	15.15 $\pm$ 0.40	14.32	16.50	16.52 $\pm$ 0.70	15.16	18.06	$p < 0.01$
Lipid (%)	6.03 $\pm$ 0.25	5.63	6.70	7.18 $\pm$ 0.47	6.37	8.4	$p < 0.01$
Ash (%)	4.58 $\pm$ 0.29	4.13	5.13	3.56 $\pm$ 0.40	2.76	4.21	$p < 0.01$
Iron	74.34 $\pm$ 6.73	54.73	83.21	48.37 $\pm$ 3.17	40.87	54.22	$p < 0.01$
Zinc	31.63 $\pm$ 3.01	26.71	36.56	20.50 $\pm$ 2.06	16.12	24.11	$p < 0.01$
Calcium	51.28 $\pm$ 5.15	44.31	58.5	34.32 $\pm$ 5.96	25.13	46.72	$p < 0.01$
Sodium	48.68 $\pm$ 2.82	42.6	54.18	43.59 $\pm$ 2.50	39.43	48.4	$p < 0.01$
Copper	9.24 $\pm$ 1.53	6.83	11.76	5.06 $\pm$ 0.62	3.83	6.13	$p < 0.01$

Use different superscript across row (Mean $\pm$ SD) to indicate significant difference

Table 3: Correlation table of *Clarias gariepinus* from Ikpoba Reservoir with Water Physico – chemical parameters.

	Moisture	Protein	Lipid	Ash	Fe	Zn	Ca	Na	Cu
pH	0.27	- 0.05	- 0.08	- 0.07	- 0.14	- 0.25	- 0.24	0.11	- 0.01
DO	0.28	0.15	0.16	- 0.19	- 0.16	0.01	- 0.04	0.20	0.03
BOD	- 0.47	- 0.04	- 0.24	0.32	0.30	0.30	- 0.17	0.21	- 0.21
Nitrate	- 0.27	- 0.02	- 0.30	- 0.22	0.35	- 0.20	- 0.35	0.22	- 0.18
Phosphate	- 0.42	- 0.28	- 0.37	- 0.47	0.30	- 0.27	- 0.40	0.33	- 0.33
Iron	- 0.41	- 0.01	- 0.22	0.22	0.17	0.05	0.04	0.07	- 0.30
Zinc	- 0.26	- 0.17	- 0.34	0.44	- 0.03	0.38	- 0.40	0.23	- 0.38
Copper	- 0.02	- 0.41	- 0.14	0.12	- 0.02	0.09	0.32	- 0.39	0.13

r 0.05. Any value > 0.113 is significant

Table 4: Correlation table of *Clarias gariepinus* from Owan River with Water Physico – chemical parameters.

	Moisture	Protein	Lipid	Ash	Fe	Zn	Ca	Na	Cu
pH	0.25	- 0.17	- 0.34	- 0.01	- 0.19	- 0.04	0.50	- 0.27	0.30
DO	- 0.04	0.30	0.14	- 0.32	- 0.24	0.40	- 0.27	0.43	- 0.18
BOD₅	0.06	- 0.01	0.06	- 0.06	0.19	-0.07	0.10	- 0.10	0.30
Nitrate	- 0.33	- 0.32	- 0.03	- 0.06	- 0.03	0.38	- 0.27	0.40	- 0.32
Phosphate	- 0.10	- 0.25	- 0.14	0.01	- 0.12	0.08	0.08	- 0.14	- 0.07
Iron	0.04	- 0.07	- 0.13	0.22	0.40	- 0.02	0.10	- 0.09	0.01
Zinc	- 0.15	- 0.28	- 0.01	0.11	- 0.34	0.20	0.03	0.12	- 0.10
Copper	- 0.15	- 0.21	- 0.05	0.27	- 0.14	0.06	0.12	- 0.02	0.15

r 0.05. Any value > 0.113 is significant.

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5

DIETARY ARACHIDONIC ACID LEVELS BLENDED WITH FISH OIL IN DIET EFFECTS ON GROWTH AND HEPATOPANCREASE FATTY ACID PROFILE IN *LITOPENAEUS VANNAMEI* (WHITE HRIMP)

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ABSTRACT

This study was aimed at evaluating dietary arachidonic acid levels blended with fish oil in diet effects on growth and hepatopancrease fatty acid profile in *Litopenaeus vannamei* (white shrimp). Five isonitrogenous and isoenergetic experimental diets with dietary arachidonic acid (ARA) levels blended with fish oil (A 0.28, B- 0.44, C- 0.56, D - 0.87 and E - 1.02 mg ARA/g diet respectively) with constant saturated fatty acids (SFA), mono-unsaturated fatty acids (MUFA) and poly-unsaturated fatty acids (PUFA) contents and n-3/n-6 ratios were formulated and fed to the white shrimp *L. vannamei* of average weight 0.77 ± 0.27 g for six weeks in hapas suspended in a concrete pond under a flow- through system. Growth and hepatopancrease fatty acid profile of the shrimp were analyzed. The results showed that dietary ARA level (from 0.28mg ARA/g diet to 1.02 mg ARA/g diet) had no significant effect on the growth, survival and feed coefficient (FCR). Dietary ARA level had significant effects on muscular proximate composition and hepatopancrease fatty acid profiles of shrimps. In conclusion, dietary ARA level did not significantly affect growth, but significantly reduces tissue muscle crude protein and increases muscle total lipid and hepatopancrease fatty acid profile in *Litopenaeus vannamei*

KEYWORDS:

INTRODUCTION

Pacific white shrimp (*Litopenaeus vannamei*) is a crustacean species cultured worldwide, producing nearly four million metric tons per year (FAO, 2018). This shrimp like other crustaceans, have a limited ability to synthesize highly unsaturated fatty acids (HUFA) from the polyunsaturated linoleic (18:2n-6) and linolenic (18:3n-3) acids (Hien *et al.*, 2005). Consequently, HUFA, such as docosahexaenoic (22:6n-3, DHA), eicosapentaenoic (20:5n-3, EPA), and arachidonic (20:4n-6, ARA) acids are considered essential and dependent on dietary supply. Marine shrimp are highly fish oil dependent, largely because of fatty acid requirement especially long-chain polyunsaturated fatty acids (LC-PUFA) from n-3 series. Docosahexaenoic acid (DHA, 22:6n-3) and eicosapentaenoic acid (EPA, 20:5n-3) are the most important LC-PUFAs for marine species.

The hepatopancreas is vital organ responsible for absorbing, storing metabolic substrates and synthesizing and secreting digestive enzymes (Araújo *et al.*, 2020). Basically, the hepatopancreas is formed by four different cells, being the most abundant R cells, where the lipid and glycogen are stored, and the B cells which

are responsible for intracellular digestion with concomitant secretory functions (Araújo *et al.*, 2020). Owing to the significance of ARA in the marine shrimp nutrition, the present study investigated the dietary arachidonic acid levels blended with fish oil on the growth and hepatopancreas fatty acid profile in *Litopenaeus vannamei*

MATERIALS AND METHODS

Diet preparation

Five isonitrogenous and isocaloric diets with similar SFA, MUFA, PUFA contents and n-3/n-6 ratio to that of fish oil supplemented with different dietary ARA levels were formulated (table 1). The dry ingredients were minced and mixed thoroughly, and distilled water added until a stiff dough was formed. The dough was passed through a meat-mincing machine to form spaghetti-like strings, and heated at 95°C (using a vacuum drying oven for 15mins, the dried diets were later crushed to smaller convenient pellet sizes.

Experimental Shrimps

One thousand (1000) healthy shrimp juvenile (0.77 ± 0.27 g) were randomly distributed into 20 net-cages ($1.2 \text{ m} \times 0.5 \text{ m} \times 1.0 \text{ m}$), which were hung in a concrete pond ($10.0 \text{ m} \times 5.0 \text{ m} \times 1.2 \text{ m}$), at a stocking density of 50 shrimp per cage. Each treatment was replicated 4 times. The shrimp were fed with their respective diets four times (05:30, 11:30, 17:30 and 23:00h) daily for 6 weeks at a feeding rate of about 5% body weight according to the feeding and growth states of the shrimp. Continuous aeration was supplied to maintain the dissolved oxygen concentration more than 6.0 mg L^{-1} and water quality parameters (Temperature, nitrite, pH, ammonia, TDS, alkalinity and EC) were monitored periodically using electronic meter and water quality kits.

Sampling Protocol

After six weeks feeding trial, prior to sampling all shrimps were starved for 24 h, 8 shrimp from each cage were randomly sampled and anaesthetized using tricaine methanesulfonate (MS-222; 100 mg L^{-1} ; Sigma, St. Louis, MO, USA), dissected for muscle and hepatopancreas. Then the muscle and hepatopancreas samples were stored at -20°C for analysis of biochemical composition and the fatty acid profiles.

Growth parameters

At the end of six-week feeding trial, shrimp in each cage were counted and weighed after starvation for 24 hours. The growth performances (WGR, SGR, survival, FER) of the shrimp were calculated. The WGR, SGR, Survival and FER were calculated as follows:

$$\text{Weight Gain Rate (WGR) (\%)} = 100 \times (W_f - W_0) / W_0$$

$$\text{Specific growth rate (SGR)} = 100 \times (\ln W_f - \ln W_0) / t$$

$$\text{Survival (\%)} = 100 \times \text{final shrimp number} / \text{initial shrimp number}$$

$$\text{Feed efficiency ratio (FER)} = (W_f - W_0) / \text{FI}$$

In which, W_f : final shrimp weight (g); W_0 : initial shrimp weight (g); t : days of the feeding trial; FI: Feed Intake.

Proximate composition and Fatty acid profile determination

The proximate compositions were determined by the standard methods of AOAC (2015). The fatty acid of diets and hepatopancreas of shrimp were determined using Fatty acid methyl esters (FAMES).

Transesterification of sample with BF₃ (14% in methanol) and detected by an HP 6890 gas chromatography according to method of Wen *et al.* (2005).

Data Analysis

Descriptive statistics was used to summarize data generated, ANOVA was used to compare means between treatments, DMRT was used to separate means where significant differences were observed at 95% confidence interval ($P < 0.05$), mortality were expressed in percentages. All statistical analyses were done using SPSS version 20.

RESULTS AND DISCUSSION

The growth performance of shrimp fed different dietary arachidonic acid levels blended with fish oil (**Table 2**) revealed that the mean final weight, survival, WGR, SGR and FER of all groups were not significantly different ($P > 0.05$), however the mean final weight increased as ARA level increased. Effect of dietary ARA level on muscle tissue composition of shrimp is presented in the **Table 2**, crude protein, total lipid, moisture differed significantly ($P < 0.05$), group A fed 0.28 mg ARA /g diet had the highest crude protein (21.07 ± 0.41) in muscle tissue, however, there was no significant difference ($P > 0.05$) in muscle tissue crude protein of group A, B, C and D. Ash content in shrimp across all groups were not significantly different. **Table 3** shows ARA levels in various diet, the ARA level in diets fed shrimp from group A, B, C and D increased with increase in inclusion level, however there was no significant difference in DHA, EPA, SFA, MUFA, PUFA, n-3PUFA, n-6PUFA and n-3/n-6 across all diets. The hepatopancrease fatty acid profile of shrimp fed different dietary ARA levels (**Table 4**) differ significantly ($P < 0.05$) in 18:2n6, 18:3n3, 18:4n3, 20:1, 20:1n9, 20:2n6, ARA, 20:4n3, 22:1n9, 22:5n9 and n-6PUFA fatty acid. The ARA, SFA, MUFA and PUFA contents were higher in group B (0.44 mg ARA / g diet) with only differences in DHA and EPA levels.

Previous studies demonstrated that ARA is more effective for the marine shrimp growth than others PUFA, being less essential than DHA and EPA. Certainly, others factors need be always considered in the growth performance evaluation during ARA levels inclusion for aquatic organisms such as, the species specificity, life phase, culture system and conditions, genetic lineage and diet composition. In this study, ARA did not significantly influence growth, which may have resulted from LC-PUFA ratios (mainly between DHA, EPA and ARA) and different fatty acid series (mainly n-3/n-6) influencing metabolic processes and consequently growth in the experimental shrimps (González-Félix *et al.*, 2003; Glencross, 2009; Araújo *et al.*, 2020). In the experimental shrimp, crude protein content in muscle decreased as ARA levels increased. The ARA content in feed affected the normal composition of *L. vannamei* muscle, an increase in dietary ARA triggered downward trend of crude protein content of shrimp muscle, while total fat showed an upward trend. High level of ARA in feed affects HUFA absorption and metabolism balance in the hepatopancrease thus limiting the growth of the shrimp.

Conclusion

In conclusion, dietary ARA level did not significantly affect growth, but significantly reduces tissue muscle crude protein and increases muscle total lipid and hepatopancrease fatty acid profile in *Litopenaeus vannamei*

Table 1: Feed Composition, ARA Level and Proximate Composition of Experimental diets

Ingredients	0% (A)	0% (B)	0.05% (C)	0.10% (D)	0.15% (E)
fish meal	22	22	22	22	22
shrimp shell meal	3.5	3.5	3.5	3.5	3.5
soybean meal	26	26	26	26	26
peanut meal	11	11	11	11	11

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blood meal	3	3	3	3	3
Flour	21.59	21.59	21.59	21.59	21.59
squid Liver	4	4	4	4	4
beer yeast cell	3	3	3	3	3
Phospholipid	1	1	1	1	1
choline chloride	0.25	0.25	0.25	0.25	0.25
premix	0.6	0.6	0.6	0.6	0.6
vitamin C	0.06	0.06	0.06	0.06	0.06
caH ₂ PO ₄	1.5	1.5	1.5	1.5	1.5
fish oil ^a	1.25	2.5	2.45	2.38	2.28
perilla oil ^b	0	0	0	0	0.03
palm oil ^b	0.58	0	0	0	0
rapeseed oil ^b	0.27	0	0	0	0
DHA oil ^c	0.4	0	0	0.02	0.04
ARA oil ^c	0	0	0.05	0.1	0.15
blended oil ^b	2.5	2.5	2.5	2.5	2.5
Proximate composition					
dry matter(mg/g)	93.66	93.66	93.66	93.66	93.66
crude protein(mg/g)	49.59	49.59	49.59	49.59	49.59
total lipid(mg/g)	10.59	10.59	10.59	10.59	10.59
ash(mg/g)	8.19	8.19	8.19	8.19	8.19
Gross energy (kcal/kg)	19299.28	19299.28	19299.28	19299.3	19299.3
ARA Content (mg/g)	0.28±0.03	0.44±0.07	0.56±0.03	0.87±0.07	1.02±0.04

mineral salt premix contains Co20-190mg,Cu200-2400mg, Zn400-14000mg,Mn200-9000mg / vitamin premix contains 10-150 million IU of vitamin A.100-5000mg vitamin B₁.100-5000mg vitamin B₂.5-39 million IU of vitamin D₃.600-30000 million IU of vitamin E. 100-15000 mg vitamin B₆.60-4000mg vitaminK3.300-50000mg niacin.200-4000mg Pantothenic acid.20-500mg Folic acid. Diet A (0% ARA level in fish + vegetable oil-based diet), B, C, D and E (0, 0.05, 0.10 and 0.15% ARA levels in fish oil-based diet).

Table 2: Growth performance and muscle tissue composition (wet weight) of shrimp *L. vannamei* fed different dietary ARA levels blended with fish oil (Means ± SD, n= 4)

	A (0.28 mg ARA/g diet)	B (0.44 mg ARA/g diet)	C (0.56 mg ARA/g diet)	D (0.87 mg ARA/g diet)	E (1.02 mg ARA/g diet)
Mean initial weight (g)	0.77±0.27 ^a	0.77±0.27 ^a	0.77±0.27 ^a	0.77±0.27 ^a	0.77±0.27 ^a
Mean final weight (g)	11.17±0.66 ^a	11.30±0.74 ^a	11.30±1.02 ^a	11.51±0.97 ^a	11.57±0.58 ^a
Survival%	85.00±7.07 ^a	79.00±4.24 ^a	84.00±1.31 ^a	83.00±1.41 ^a	83.00±7.07 ^a
WGR	1416.8±86.4 ^a	1382.3±95.8 ^a	1458.7±105.7 ^a	1513.8±126.5 ^a	1383.0±75.6 ^a
SGR	24.77±1.58 ^a	25.06±1.76 ^a	25.07±2.43 ^a	25.58±2.32 ^a	23.33±1.39 ^a
FER	0.8±0.11 ^a	0.82±0.2 ^a	0.78±0.13 ^a	0.75±0.11 ^a	0.82±0.11 ^a
Crude protein (%)	21.07±0.41 ^a	20.05±0.60 ^{ab}	20.61±1.39 ^{ab}	20.88±0.27 ^{ab}	19.51±0.15 ^b
Ash, %	1.39±0.02	1.33±0.00	1.36±0.02	1.37±0.02	1.39±0.08
Total lipid, %	0.43±0.14 ^c	0.48±0.21 ^{bc}	0.51±0.05 ^{bc}	0.89±0.05 ^a	0.81±0.13 ^{ab}
Moisture, %	72.38±0.74 ^b	74.05±0.53 ^a	73.20±0.77 ^b	73.24±0.31 ^b	73.38±0.42 ^b

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Mean $\pm$ SD with different superscript (a, b, c,) are significantly different ($P \leq 0.05$)

Table 3: Fatty acids profile of the diets formulated with different ARA levels blended with fish oil *(mg/g, Means $\pm$ SD, n= 3)

fatty acid	A (0.28 mg ARA/g diet)	B (0.44 mg ARA/g diet)	C (0.56 mg ARA/g diet)	D (0.87 mg ARA/g diet)	E (1.02 mg ARA/g diet)
14:00	0.70 $\pm$ 0.04	0.70 $\pm$ 0.07	0.71 $\pm$ 0.31	0.57 $\pm$ 0.02	0.56 $\pm$ 0.06
15:00	0.08 $\pm$ 0.01	0.05 $\pm$ 0.00	0.07 $\pm$ 0.00	0.06 $\pm$ 0.01	0.07 $\pm$ 0.01
16:00	8.18 $\pm$ 0.29	7.23 $\pm$ 0.37	7.66 $\pm$ 0.46	6.50 $\pm$ 0.46	7.31 $\pm$ 0.53
16:1n9	0.08 $\pm$ 0.00	0.07 $\pm$ 0.00	0.08 $\pm$ 0.01	0.06 $\pm$ 0.01	0.08 $\pm$ 0.01
16:1n7	1.43 $\pm$ 0.14	1.45 $\pm$ 0.06	1.90 $\pm$ 0.45	1.16 $\pm$ 0.05	1.25 $\pm$ 0.11
17:00	0.13 $\pm$ 0.01	0.08 $\pm$ 0.01	0.15 $\pm$ 0.03	0.10 $\pm$ 0.01	0.12 $\pm$ 0.02
16:4n1	0.17 $\pm$ 0.02	0.25 $\pm$ 0.05	0.17 $\pm$ 0.02	0.13 $\pm$ 0.01	0.15 $\pm$ 0.03
18:00	1.39 $\pm$ 0.19	1.03 $\pm$ 0.13	1.22 $\pm$ 0.09	1.09 $\pm$ 0.1	1.33 $\pm$ 0.06
18:1n9	6.08 $\pm$ 0.76	6.04 $\pm$ 0.56	5.53 $\pm$ 0.50	4.76 $\pm$ 0.20	5.51 $\pm$ 0.07
18:1n7	0.78 $\pm$ 0.06	0.77 $\pm$ 0.07	0.77 $\pm$ 0.09	0.66 $\pm$ 0.04	0.71 $\pm$ 0.07
18:2n6	7.90 $\pm$ 0.65	10.5 $\pm$ 0.74	9.88 $\pm$ 1.95	6.03 $\pm$ 0.32	8.00 $\pm$ 0.20
18:3n3	0.26 $\pm$ 0.38	1.18 $\pm$ 0.45	0.74 $\pm$ 0.12	0.63 $\pm$ 0.02	0.79 $\pm$ 0.05
18:4n3	0.49 $\pm$ 0.04	0.54 $\pm$ 0.10	0.49 $\pm$ 0.08	0.4 $\pm$ 0.03	0.48 $\pm$ 0.03
20:1n9	0.61 $\pm$ 0.07	0.63 $\pm$ 0.08	0.55 $\pm$ 0.10	0.48 $\pm$ 0.10	0.57 $\pm$ 0.03
20:2n6	0.08 $\pm$ 0.00	0.09 $\pm$ 0.01	0.07 $\pm$ 0.02	0.06 $\pm$ 0.01	0.07 $\pm$ 0.00
20:4n3	0.16 $\pm$ 0.01	0.16 $\pm$ 0.02	0.16 $\pm$ 0.10	0.13 $\pm$ 0.04	0.16 $\pm$ 0.01
21:5n3	0.39 $\pm$ 0.04	0.46 $\pm$ 0.09	0.35 $\pm$ 0.04	0.31 $\pm$ 0.02	0.39 $\pm$ 0.05
ARA	0.28 $\pm$ 0.03 ^e	0.44 $\pm$ 0.07 ^d	0.56 $\pm$ 0.03 ^c	0.87 $\pm$ 0.07 ^b	1.02 $\pm$ 0.04 ^a
DHA	6.07 $\pm$ 0.10	5.72 $\pm$ 0.52	5.9 $\pm$ 0.80	5.81 $\pm$ 0.11	5.77 $\pm$ 0.03
EPA	3.91 $\pm$ 0.32	3.96 $\pm$ 0.28	3.81 $\pm$ 0.50	3.75 $\pm$ 0.68	3.71 $\pm$ 0.22
SFA	10.48 $\pm$ 0.24	9.39 $\pm$ 0.52	10.21 $\pm$ 0.72	8.56 $\pm$ 0.42	9.75 $\pm$ 0.63
MUFA	8.98 $\pm$ 1.00	9.3 $\pm$ 0.58	8.73 $\pm$ 0.93	6.94 $\pm$ 0.34	8.29 $\pm$ 0.24
PUFA	20.28 $\pm$ 0.41	21.89 $\pm$ 0.44	20.08 $\pm$ 0.62	19.17 $\pm$ 0.83	20.36 $\pm$ 0.37
n-3PUFA	11.29 $\pm$ 0.56	11.98 $\pm$ 0.38	11.28 $\pm$ 1.43	10.5 $\pm$ 0.72	11.32 $\pm$ 0.17
n-6PUFA	8.99 $\pm$ 0.65	9.91 $\pm$ 1.74	8.8 $\pm$ 1.94	8.67 $\pm$ 0.12	9.04 $\pm$ 0.17
n-3/n-6	1.26 $\pm$ 0.05	1.21 $\pm$ 0.05	1.28 $\pm$ 0.03	1.21 $\pm$ 0.01	1.25 $\pm$ 0.80

Mean $\pm$ SD with different superscript (a, b, c,) are significantly different ($P \leq 0.05$)

Table 4: Hepatopancreas fatty acid profile of *L. vannamei* fed different dietary ARA level blended with fish oil (mg/g, Means $\pm$ SD, n= 3)

Fatty acids	A (0.28 mg ARA/g diet)	B(0.44 mg ARA/g diet)	C(0.56 mg ARA/g diet)	D(0.87 mg ARA/g diet)	E(1.02 mg ARA/g diet)
12:0	0.01 $\pm$ 0.00	0.01 $\pm$ 0.00	0.01 $\pm$ 0.00	0.01 $\pm$ 0.00	0.01 $\pm$ 0.00
14:0	1.92 $\pm$ 0.32	1.87 $\pm$ 0.1	2.11 $\pm$ 0.20	2.00 $\pm$ 0.18	1.92 $\pm$ 0.28
15:0	0.50 $\pm$ 0.07	0.44 $\pm$ 0.04	0.54 $\pm$ 0.04	0.50 $\pm$ 0.06	0.49 $\pm$ 0.04
16:0	24.72 $\pm$ 3.65	25.32 $\pm$ 1.24	26.63 $\pm$ 3.04	24.11 $\pm$ 3.73	24.31 $\pm$ 2.37
16:1n9	0.35 $\pm$ 0.07	0.36 $\pm$ 0.05	0.42 $\pm$ 0.02	0.38 $\pm$ 0.06	0.35 $\pm$ 0.03
16:1n7	4.20 $\pm$ 0.64	4.58 $\pm$ 0.44	4.88 $\pm$ 0.49	4.40 $\pm$ 0.72	4.23 $\pm$ 0.36
17:0	0.66 $\pm$ 0.11	0.59 $\pm$ 0.07	0.72 $\pm$ 0.01	0.66 $\pm$ 0.06	0.65 $\pm$ 0.06
18:0	3.55 $\pm$ 0.53	3.36 $\pm$ 0.21	3.84 $\pm$ 0.12	3.65 $\pm$ 0.30	2.28 $\pm$ 1.95

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18:1n7	3.82±0.61	4.21±0.39	4.35±0.36	3.91±0.58	3.81±0.22
18:1n9	20.50±3.27	24.20±1.97	22.07±2.54	20.04±3.67	20.28±1.70
18:2n6	19.22±3.08 ^b	24.34±1.51 ^a	19.00±2.05 ^b	18.22±3.04 ^b	18.46±1.72 ^b
18:3n3	1.10±0.01 ^c	1.83±0.22 ^a	1.53±0.06 ^{ab}	1.47±0.28 ^{bc}	1.46±0.16 ^{ab}
18:4n3	0.34±0.05 ^b	0.46±0.08 ^a	0.35±0.01 ^a	0.35±0.05 ^b	0.33±0.07 ^b
20:0	0.35±0.04 ^{ab}	0.29±0.01 ^b	0.36±0.01 ^a	0.36±0.04 ^a	0.35±0.04 ^{ab}
20:1n9	1.50±0.09 ^{ab}	1.78±1.00 ^a	2.13±0.20 ^a	0.51±0.09 ^b	0.48±0.02 ^b
20:2n6	1.36±0.34 ^b	2.07±0.17 ^a	1.40±0.05 ^b	1.32±0.41 ^b	1.27±0.09 ^b
ARA	0.97±0.12 ^d	1.33±0.03 ^c	1.49±0.18 ^c	1.90±0.15 ^b	2.14±0.05 ^a
20:4n3	0.49±0.08 ^b	0.72±0.04 ^a	0.49±0.05 ^b	0.46±0.12 ^b	0.44±0.04 ^b
EPA	5.99±0.99	6.28±0.55	5.96±0.37	5.82±0.14	6.19±0.88
22:0	0.44±0.06	0.43±0.03	0.39±0.02	0.37±0.08	0.41±0.07
22:1n9	0.93±0.14 ^{ab}	1.14±0.02 ^a	0.96±0.05 ^{ab}	0.89±0.15 ^b	0.87±0.16 ^b
22:5n3	1.02±0.12 ^{ab}	1.63±0.08 ^a	1.02±0.09 ^{ab}	0.97±0.21 ^b	0.98±0.12 ^b
DHA	11.05±1.29	10.05±0.71	10.52±1.18	10.48±1.49	10.97±1.32
n-3PUFA	19.98±2.52	20.97±0.51	20.01±1.81	19.55±2.27	20.52±2.59
n-6PUFA	22.71±3.39 ^{ab}	27.38±1.79 ^a	20.55±1.88 ^b	21.02±3.61 ^b	21.63±1.86 ^b
SFA	32.15±4.74	32.32±1.66	33.46±1.66	31.66±4.44	30.41±2.57
MUFA	31.31±5.07	36.26±1.96	34.15±2.68	30.13±5.26	30.03±2.40

Mean ± SD with different superscript (a, b, c) are significantly different ($P \leq 0.05$)

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6

GROWTH PERFORMANCES AND COST ANALYSES OF AFRICAN CATFISH, *CLARIAS GARIOPINUS* (BURCHELL, 1822) FINGERLINGS FED GRADED LEVELS OF TILAPIA, *COPTODON ZILLI* WASTE MEAL DIETS

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ABSTRACT

Feeding trial was conducted to investigate the effect of fish waste meal on growth performance and nutrient utilization of *Clarias gariepinus*. 100 fingerlings of *C. gariepinus* were stocked. Five (5) iso-nitrogenous diets containing 40% crude protein in which fish meal protein (70%) was replaced by fish waste meal protein (52%) at 0%, 25%, 50%, 75% and 100% levels were formulated. The fingerlings were fed at 5% body weight per day for 56 days. Growth performance, feed utilization and cost benefit parameters showed that fish fed 50% waste meal gave the best weight gain (66.4%), the least was obtained in those fed 75% Diet. Feed intake showed where highest value was obtained in fish fed diet with 50% inclusion level (18.85g) while the lowest was obtained in fish fed Control (0% fish waste meal) as 16.92g. Net protein utilization fish fed diet containing 50% Fish waste meal had higher value (1129.17) among other diets. Based on the findings from this result, 50% inclusion of Tilapia waste meal is ideal in the economical diet of *Clarias gariepinus* without compromising the weight and health

KEYWORDS: Growth, Feed Utilization, Fish meal, Tilapia waste, Cost analysis

Introduction

Many scientists have reported the possible use of some alternative animal protein feedstuffs to fish meal such as Earthworm meal (Sogbesan *et al.*, 2005), Toad meal (Sogbesan *et al.*, 2007), Live maggot (Sogbesan, 1998), Dry Maggot meal (Ugwumba *et al.* 2001 and Sogbesan *et al.*, 2005), Poultry dung meal (Fasakin *et al.*, 2000), Garden snail meal (Sogbesan and Ugwumba, 2006), Termite meal (Sogbesan and Ugwumba, 2008). The projected human population in Nigeria from year 2000 to year 2019 is 114.4 to 200 million. Nigeria is the 8th leading country in inland capture fisheries in 2016 with 337,632MMT and the second largest in Aquaculture production in Africa after Egypt (SOFIA, 2018) though these have not been able to outweigh the demand by the populace. Production of fish from aquaculture is therefore seen as the only remedy to this problem since capture from the wild is dwindling by the day as a result of depletion in stock while the population is on the increase. Hence, the challenge is to bridge the wide gap between fish demand and supply, in order to meet the population growing demand for fish in Nigeria (Akinrotimi *et al.*, 2011).

The nutritional requirements for growth, reproduction and normal physiological functions of fish are similar to those of other animals, but generally more protein is required in the diet of fish. Due to this, the efficiency in the use of proteins is more significant to fish than other animals. So, feed mixtures with 25 to 55% of proteins are mainly used, depending on species, sex and age of the fish (Davies and Gouevia, 2010). Tilapia fish wastes can be defined as tilapia species, undersized or damaged commercial species products having low commercial value.

MATERIALS AND METHOD

The experiment was carried out in the Department of Fisheries Research farm of Kano University of Science and Technology Wudil.

One hundred and fifty fingerlings of catfish, *Clarias gariepinus* with average weight of 4.25 ± 0.15 g were obtained from a reputable Hatchery in Kano State, Nigeria. The fish were transferred to the wet laboratory and acclimatized for one week. They were then starved for 12 hours prior to being placed on the experimental diets.

Diets were formulated to contain 40% crude protein. Fish-meal was replaced by Tilapia waste meal (TWM) at 0% TWMD – control, 25% TWMD, 50% TWMD, 75% TWMD and 100% TWMD. Dried Tilapia waste was collected from Wudil market, Kano, Nigeria. They comprised discarded heads, fins, skin and entrails of smoke fish (*Coptodon zillii*). The ingredients for each diet were mixed thoroughly in a bowl and pelletized in a manually-operated pelletizer. The moist pellets were shade-dried, Packaged in tagged air-tight polythene bags and stored in a dry place at room temperature. After preparing the ingredients, they were weighed and mixed in appropriate proportions to give the desired protein level required by the fish. The fish were fed 5% body weight twice daily by 7.00 am and 5pm and quantity adjusted based on the weekly weight for 8 weeks. Water quality parameters that were monitored during the experiment are pH, Temperature, Dissolved Oxygen and Ammonia.

The growth and feed utilization and cost benefit analyses indices were determined according to Sogbesan and Ugwumba (2006).

Data Analysis

Raw data generated were subjected to descriptive analysis while means were separated using One way analysis of variance (ANOVA) for significance difference at 5% with Minitab Statistical package for windows 10.

RESULTS AND DISCUSSION

The growth pattern of the *C. gariepinus* fed the experimental diets shows a continuous increase from the first week to the end of the experiment. The final mean weight of the experimental fish ranged between 10.48 g/fish to 15.85g/fish. There were significant differences ($p \leq 0.05$) between the weight of the fish at lower inclusion and higher inclusion levels. The highest relative weight gain of 273.85% was recorded in the control and the lowest of 144.86% in fish fed 75%TWMD and these were significantly difference ($p \leq 0.05$). The specific growth rate ranged between 1.023%/day to 0.694%/day and these were significantly different ($p \leq 0.05$). The highest Net profit value was recorded in fish fed 50% TWMD followed by those fed 25% diet and the lowest in 75% diet. The highest investment cost analysis value of N595.05 was recorded in fish fed control diets and the lowest in those fed 100% TWMD and these values were significantly difference ($p \leq 0.05$). The benefit cost ratio ranged from 1.96 to 1.36 and were all significant different ($p \leq 0.05$) with the control apart from 25% TWMD.

The fact that all the fish grew is an indication the experimental diets tested contained the required nutrients needed by the fish. The fact that weight gain was reported in all the treatments was an indication that the fish responded positively to all the diets and that the protein content of the experimental diets adequately provided for growth and dietary energy supply of the fish (Fagbenro and Arowosoge, 1991). This was in accordance with the report of Tacon (1994) that fishmeal could be replaced with tilapia waste meal in fish feed without any adverse effect on the weight gain by the fish fed. The condition factors at the end of the experimental showed that the feeds were properly utilized for better growth and health in the control to 50% graded levels of TWMD than in 75% and 100% graded levels of TWMD since all the condition factors for fish fed the latter were above 1.0 (Lagler, 1956). Condition factor even in the wild is not constant for individuals, species

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or population but is subject to wide variations. For fish, Wade (1992) gave 1.0 as the best natural condition factor and the result from this study reported better condition factor than the natural.

The amount of protein consumed by fish is regulated by certain conditions documented by Lovell (1984) as size of fish, physiological function, protein quality and non-protein requirement.

Table1. Feed compositions of the experimental diets (% dry matter weight)

Ingredients	Control 0% TWMD	25% TWMD	50% TWMD	75% TWMD	100% TWMD
Inclusion levels	0%	25%	50%	75%	100%
Fish meal	21.91	16.42	10.96	5.48	0.00
Fish waste meal	0.00	5.48	10.96	16.43	21.91
Groundnut cake meal	21.91	21.91	21.91	21.91	21.91
Soybean meal	21.91	21.91	21.91	21.91	21.91
Maize meal	27.76	27.76	27.76	27.76	27.76
Vitamin premix	1.00	1.00	1.00	1.00	1.00
DCP	0.50	0.50	0.50	0.50	0.50
Salt	1.0	1.0	1.0	1.0	1.0
Palm oil	5.00	5.00	5.00	5.00	5.00
Total	100	100	100	100	100
Calculated Crude Protein	40.00	40.00	40.00	40.00	40.00
Cost of Feed (N/kg)	185.04	180.66	176.30	171.90	167.51

Table2. Growth performances and survival rate of *Clarias gariepinus* Fingerlings Fed with Tilapia Waste Diets for 56 Days

Parameters	Control	25%TWMD	50%TWMD	75%TWMD	100%TWMD
Mean Initial Weight (g)	4.24	4.24	4.26	4.28	4.27
Mean Final Weight (g)	15.85 ^a	14.36 ^a	14.06 ^a	10.48 ^b	11.04 ^b
Mean Weight Gain (g)	11.61 ^a	10.12 ^a	9.86 ^a	6.20 ^b	6.77 ^b
Relative Weight Gain (%/fish)	273.82 ^a	237.56 ^a	231.46 ^a	144.86 ^b	158.55 ^b
Specific Growth Rate (%/day)	1.023 ^a	0.946 ^a	0.926 ^a	0.694 ^b	0.737 ^b
Initial Mean Length (cm/fish)	5.20 ^a	5.10 ^a	5.20 ^a	5.30 ^a	5.10 ^a
Final Mean Length (cm/fish)	11.50 ^a	11.30 ^a	11.00 ^{ab}	10.90 ^b	11.10 ^{ab}
Initial Condition factor (K ₁)	3.02 ^a	3.20 ^a	3.03 ^a	2.87 ^b	3.22 ^a
Final Condition factor (K ₂)	1.04 ^a	1.00 ^a	1.06 ^a	0.81 ^b	0.81 ^b
Survival rate	100 ^a	100 ^a	98 ^a	90 ^b	80 ^c
Mean Protein Intake	7.33 ^a	4.86 ^b	4.06 ^b	2.13 ^c	2.03 ^c
Protein Efficiency Ratio	1.58 ^d	2.08 ^c	2.43 ^b	2.91 ^b	3.33 ^a
Mean Feed intake	18.34 ^a	12.14 ^b	10.16 ^b	5.33 ^c	5.08 ^c
Feed conversion ratio	1.58 ^a	1.20 ^b	1.03 ^c	0.86 ^d	0.75 ^d
Net profit value (N/kg)	1037.24 ^c	1091.20 ^b	1129.17 ^a	778.86 ^e	814.43 ^d
Investment cost analysis (N)	595.04 ^a	580.66 ^b	576.30 ^c	571.90 ^{cd}	567.51 ^d
Gross profit/loss (N)	442.2 ^c	510.52 ^b	552.87 ^a	206.04 ^d	246.92 ^d

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Incidence of cost	100.02 ^a	85.18 ^b	62.29 ^c	58.12 ^{cd}	48.71 ^d
Profit index	2.162 ^b	2.294 ^a	2.298 ^a	2.126 ^b	2.147 ^b
Benefit Cost ratio (r)	1.77 ^b	1.86 ^{ab}	1.96 ^a	1.36 ^c	1.43 ^c

Means of data on the same row with different superscripts are significantly different ($p \leq 0.05$)

The results on protein intake and protein efficiency rate varied according to the inclusion of the tilapia waste meal. These conditions are tied to the general energy requirement at a given water temperature.

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7

GROWTH PERFORMANCE OF AFRICAN CATFISH (*CLARIAS GARIEPINUS* BURCHELL, 1822) FINGERLINGS FED GRADED LEVELS OF WHEAT (*TRITICUM SPP*) BRAN MEAL DIETS

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ABSTRACT

The efficacy of wheat (*Triticum spp*) bran meal as an ingredient in diet of the African catfish, *Clarias gariepinus* was evaluated for a 56-day (8 weeks) growth period. Five isonitrogenous (40% protein) experimental diets were formulated at 0% (control), 25%, 50%, 75% and 100% inclusion levels of wheat bran meal. The 56-day feeding experiment was conducted in 20 Litres plastic bowls, each treatment in triplicates. One hundred and fifty *Clarias gariepinus* fingerlings with average mean weight of 4.61 ± 0.10 g were stocked at 10 fingerlings per bowl for each treatment. The fish were fed 5% body weight twice per day, monitored for weekly growth and mortality. Data collected were analyzed using One-way ANOVA. Fish fed 100% wheat bran meal recorded the best growth performance in body weight gain, Specific Growth Rate (SGR), and Feed conversion Ratio (FCR). The lowest incidence of cost (111.79) and lowest profit index (1.99) were from the control diet and the highest profit index (2.08) was from 100% wheat bran meal diet.

KEYWORDS: Maize, Wheat Bran, *Clarias gariepinus*, Growth, Cost Analysis

INTRODUCTION

The importance of aquaculture in improving the diet of the people, generating employment, conserving foreign exchange and reducing fish importation has increased greatly (Adewumi, 2015). For aquaculture industry sustainability, apart from developing and improving of manpower; it is of immense importance to research and develop on various inputs of production, such as feed and seeds. The need for feed improvement is becoming increasingly urgent because feeds accounted for about 60% of the total cost of production (State of Fisheries and Aquaculture, SOFIA (2018). In Nigeria, emphasis has been placed on spurring indigenous feed enterprises that make use of local ingredients in formulating feeds for the fish industry (Sogbesan and Ugwumba, 2008 and Sogbesan, 2014, Ityumbe *et al.*, 2021). The task of meeting the increasing demand for fish feed can be best actualized through increased availability of indigenous feed production (Eyo, 2003). Indigenous feed enterprise is seen as an honest approach because of ease of availability of raw materials for feed production and access by fish farmers (Udo and Dickson, 2017).

Maize for long has been the usual dietary energy source in formulating animal feed. However, rising cost and scarcity in the context of competitions by other domestic animals and human usages are making it increasingly uneconomical to include it in animal feed. Therefore, there is an urgent need to sort for other suitable ingredients that can serve as dietary energy source in the place of maize without comprising the growth and health of fish (Sogbesan *et al.*, 2016). Wheat (*Triticum spp.*) bran is the coarse outer covering of the wheat. Wheat bran contributes bulk to animal feeds and is a known reliable source of carbohydrates, protein, vitamins and minerals. Generally, wheat bran has been reported to have moisture - 9.67%; crude protein - 15.75%; crude fat -3.77%; crude fibre -10.38%, ash - 4.18%; and iron - 64.6mg/kg (Butt *et al.*, 2004). Hence, this study aimed at replacing maize with wheat bran meal in the diet of *Clarias gariepinus* for sustainable aquaculture

MATERIALS AND METHODS

The experiment was conducted at the Fisheries Research farm of Kano University of Science and Technology, Wudil. Feedstuffs were procured from a Wudil feedstuff market, Wudil.

One hundred and sixty (160) fingerlings of *Clarias gariepinus* of equal size (4.7 ± 0.2 g) were purchased from Sovet Agro Farm, Tarauni, Kano state. The experiment lasted for 8 weeks (56 days). A completely randomized design was used, where one hundred and fifty fingerlings were randomly allocated to five experimental diets stocked at 10 fingerlings *Clarias gariepinus* per bowl.

All the ingredients used were procured from feedstuff outlet at Abubakar Tafawa Balalewa road off Murtala Muhammad Way, Kano. The wheat bran was obtained from a milling outlet at Wudil market around the University area and proximate composition was carried out.

Proximate analysis of food is the determination of the nutrient composition of food, which includes moisture, crude lipid (fat), ash, crude protein, carbohydrate and crude fibre, AOAC (2012).

Basal diets of 40% crude protein were formulated from the commercial ingredients (fish meal, Soybean meal, yellow maize, Vitamin, Minerals, Palm oil, dicalcium phosphate and starch). Then, four experimental diets were formulated where graded levels of wheat bran meal (WBM) was used to supplement a major dietary energy, maize at 25%, 50%, 75% and 100%. The experimental diets were coded 0%WBM diet – control, 25%WBM diet, 50% WBM diet, 75% WBM diet and 100% WBM diet. The dry ingredients were milled with grinding machine to very fine particle size and sieved. The milled ingredients were weighed according to the formulation (Table 1) and mixed to homogeneity and pelleted with a pelleting machine with 0.2mm diameter size. The pellets were air dried at room temperature and stored in a refrigerator until the commencement of the feeding.

The setup comprised of five experimental diets in triplicates. A total of sixty (60) circular plastic bowls of 35 litres capacity were used. The bowls were cleaned, disinfected with saline solution and allowed to dry for 24 hours, after which water was supplied to two-third of their sizes through the overhead tank and were covered with wire net of mesh size 3mm to prevents the fishes from jumping out of the bowls and predators.

The fish in each of the bowls were fed 5% of the body weight. This changes every week as the new weights were used to determine the quantity of feed fed. The feed was administered twice a day by 7:00 am and 5:00 pm. Uneaten feeds were siphoned and water changed were day interval to avoid pollution

Data Collection and Analysis

The weights of the fish were measured before the commencement of the experiment and on weekly basis. Dead fish were recorded and discarded. Lengths of the fish were taken at the beginning and end of the experiment. Growth and Feed Utilization Indices such as: Mean weight gain, Survival (%), Condition factor (k), Specific growth rate (g/day), Feed Intake, Feed Conversion Ratio, Protein Efficiency Rate and Cost benefit analysis using the method of Sogbesan and Ugwumba (2008), based on the current market price of the ingredients used for the formulating the diets and fish cultured; and also farm-gate price of catfish and indices are: Estimated Investment Cost Analysis., Net Profit Value (NPV); Gross profit/loss (N); Incidence of cost; and Benefit Cost Ratio (BCR).

Descriptive statistics which involves the use of means and standard deviation were used to analyze the growth performance of *Clarias gariepinus* fed graded levels of wheat bran as a replacement of maize. Means of data gathered will be analyzed using Analysis of Variance (ANOVA) and the means from the various treatments will be separated for significant differences using LSD at 5% probability level.

RESULTS AND DISCUSSION

The growth pattern of the *C. gariepinus* fed wheat bran meal graded diets shows a continuous increase from the first week to the end of the eight week. The feed intake ranged from 27.65g/fish as recorded in 100% WBM diet followed by 23.67g/fish from 50% WBM diet while feed conversion ratio 1.90 were from 100% WBM diet. The net profit ranged from N674.98/kg of fish to N1,073.41/kg of fish and these two value were significantly different ($p \leq 0.05$) The highest investment cost analysis of N601.22 was recorded in fish fed the control diet, followed by N594.77 for those fed 25% WBM diet and the lowest for fish fed 100% WBM diet. These two extremes were significantly different. The best profit index of 2.08 and benefit cost ratio of 1.98 were recorded in catfish fed 100% WBM diet.

The proximate composition of the wheat bran meal is within the proximate values recommended for dietary energy source since the crude protein was less than 20.0% according to Eyo (2003) and Sogbesan and Ugwumba (2008). The fact that the wheat bran meal was not subjected to any processing method before

being used for the feed formulation might contain some anti-nutritional factors which had earlier been reported by Hossain *et al.* (2013).

The continuous weekly growth of the experimental fish from all the diets was an indication that the experimental diets contain crude protein value recommended for catfish at fingerling stage and the inclusion of the wheat bran meal didn't compromise the protein value rather showed an increase as the inclusion of the wheat bran meal increased in the formulated diet. Serna-Saldivar (2010) had earlier documented that the extracted wheat bran can be used as food supplement and livestock feed. It can also be milled with the rest of the wheat kernel components for whole wheat flour, but this takes more mechanical energy and resources. The highest weigh gain in fish fed 100% WBM could have been as result of higher crude protein documented for wheat bran meal (Table 2). The best profit index of 2.08 and benefit cost ratio of 1.98 were recorded in catfish fed 100% WBM diet agreed with the work of other scientist. Fagbenro *et al.* (2010) showed the need to use plant meal in combined form to produce the cheapest and required nutrient for fish. Sogbesan and Ekundayo (2014) reported that reduction in cost of production of the experimental diets from ₦266.20 in diet 1(control) to ₦242.20 in fermented experimental diets (2, 3, 4 and 5), is an indication of the cost effectiveness of using groundnut shells as non-conventional feedstuff in fish feed formulation. This is similar to the report that non-conventional feed resources (NCFRs) are very cheap by-products or wastes from agriculture, farm-made feeds and processing industries (Sogbesan, 2014).

Table 1. Gross Compositions of the Experimental Diets (% Dry Matter Weight)

INGREDIENTS	% WBM	25% WBM	50%WBM	75% WBM	100% WBM
FISH MEAL	21.91	21.91	21.91	21.91	21.91
SOYBEAN MEAL	21.91	21.91	21.91	21.91	21.91
GROUNDNUT CAKE	21.91	21.91	21.91	21.91	21.91
MAIZE	27.76	20.82	13.88	6.94	0.00
WHEAT BRAN	0.00	6.94	13.88	20.82	27.76
SALT	1.0	1.0	1.0	1.0	1.0
LYSINE	0.5	0.5	0.5	0.5	0.5
METHIONINE	0.5	0.5	0.5	0.5	0.5
STARCH	2.0	2.0	2.0	2.0	2.0
DICALCIUM	0.5	0.5	0.5	0.5	0.5
PHOSPHATE	1.0	1.0	1.0	1.0	1.0
VITAMIN PREMIX	1.0	1.0	1.0	1.0	1.0
PALM OIL					
TOTAL	100	100	100	100	100
CALCULATED C P	39.40	39.95	40.01	40.06	40.12
COST OF FEED (₦/KG)	201.22	199.04	196.86	194.68	192.5

Table 2. Growth and Feed Utilization of *Clarias gariepinus* Fingerlings Fed Wheat Bran Meal Diets for 56 Days

Parameters	Control (0% WBM) diet	25% WBM diet	50% WBM diet	75% WBM diet	100% WBM diet
Total Initial Weight (g)	46.70 ^a	47.65 ^a	45.30 ^a	47.10 ^a	43.50 ^a
Mean Initial Weight (g)	4.67 ^a	4.76 ^a	4.53 ^a	4.71 ^a	4.35 ^a
Total Final Weight (g)	175.60 ^a	164.0 ^a	141.44 ^b	122.40 ^c	151.2 ^b
Mean Final Weight (g)	17.56 ^b	16.4 ^{bc}	17.68 ^b	15.30 ^c	18.90 ^a

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Mean Weight Gain (g)	12.89 ^c	11.63 ^d	13.15 ^b	10.59 ^e	14.55 ^a
Relative Weight Gain (%/fish)	276.02 ^c	243.82 ^d	290.29 ^b	224.84 ^e	334.48 ^a
Specific Growth Rate (g/day)	1.027 ^b	0.958 ^c	1.056 ^b	0.914 ^c	1.139 ^a
Initial Mean Length (cm/fish)	5.90 ^a	5.80 ^a	5.70 ^a	5.60 ^a	5.10 ^a
Final Mean Length (cm/fish)	13.87 ^b	13.30 ^{bc}	13.96 ^b	12.60 ^b	15.18 ^a
Protein Intake	6.86 ^c	6.41 ^c	9.47 ^b	4.75 ^d	11.09 ^a
Protein Efficiency Ratio	1.88 ^b	1.81 ^b	1.39 ^c	2.23 ^a	1.31 ^c
Initial Condition factor (K ₁)	2.274 ^b	2.445 ^b	2.446 ^b	2.682 ^b	3.280 ^a
Final Condition factor (K ₂)	1.520 ^b	1.435 ^c	1.538 ^b	1.308 ^d	1.849 ^a
Feed Intake	17.40 ^b	16.04 ^b	23.67 ^a	11.86 ^c	27.65 ^a
Survival (%)	100 ^a	100 ^a	80 ^b	80 ^b	80 ^b
Feed conversion ratio	1.35 ^b	1.38 ^b	1.80 ^a	1.12 ^c	1.90 ^a
Net profit value (N/kg)	798.48 ^c	727.37 ^c	952.46 ^b	674.98 ^d	1073.41 ^a
Investment cost analysis (N)	601.22 ^a	594.77 ^a	588.31 ^{ab}	581.86 ^{bc}	575.4 ^c
Gross profit/loss (N)	197.26 ^d	232.6 ^c	354.15 ^b	193.12 ^d	498.01 ^a
Incidence of cost	141.79 ^b	158.48 ^b	194.9 ^a	193.1 ^a	190.28 ^a
Profit index	1.79 ^c	1.91 ^b	2.03 ^a	2.01 ^a	2.08 ^a
Benefit Cost ratio (r)	1.67 ^b	1.68 ^c	1.87 ^b	1.67 ^c	1.98 ^a

Means of data on the same row with different superscripts are significantly different (p≤0.05)

Keys: 0% WBM diet – Control – 0% Wheat Bran Meal Diet; 25% WBM diet – 25% Wheat Bran Meal Diet; 50% WBM diet – 50% Wheat Bran Meal Diet; 75% WBM diet – 75% Wheat Bran Meal Diet; 100% WBM diet – 100% Wheat Bran Meal Diet

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MODIFICATION OF COTTON SEED CAKE AS A FEED RESOURCE THROUGH DETOXIFICATION FOR USE IN *CLARIAS GARIEPINUS* FISH FEEDS

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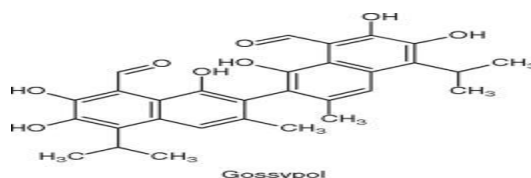
ABSTRACT

Forty-two days study was carried out to investigate the influence of detoxified cotton seed cake (CSC) as a replacement for soybean meal in the diet on growth performance of *Clarias gariepinus* fingerling. The detoxification methods employed were 48hours, 72hours of fermentation and 1000mg and 1500mg levels of iron sulphate treatments which were compared to a control without CSC and untreated CSC. Six treatments were studied in a randomized design at the hatchery complex of NIFFR, New Bussa, Niger State, Nigeria. There were significant differences in weight gain and all other growth parameters. The group that fed on iron (Fe) treated cottonseed cake had significantly ($P < 0.05$) higher weight gain compared to the group that fed on fermented, untreated cottonseed cake (CSC) and even the control. However there were no significant differences between the groups that fed on the control diet, untreated and fermented cottonseed cake in terms of weight gain. The significantly ($P < 0.05$) best feed conversion ratio (FCR) was observed in the group that fed on diet with 1g $\text{Fe}_2\text{SO}_4/\text{Kg}$ of cottonseed cake with the significantly poorest FCR obtained in the group that fed on diet with untreated CSC. There was no significant difference ($P > 0.05$) between the groups that fed on the control, fermented and higher Fe_2SO_4 treated CSC inclusion in terms of FCR. The total length and standard length also showed significant variation ($P < 0.05$). The packed cell volume, haemoglobin levels and whole body proximate composition were significantly better in the groups that fed on the control diet and that with 1g iron sulphate treated CSC ($P < 0.05$) while these parameters were significantly lower in the groups that fed on fermented and untreated CSC ($P < 0.05$). The gossypol analysis showed that the free and total gossypol content were in the range of 0.075 – 0.09mg/Kg and 0.6 - 0.75mg/Kg respectively for the iron and fermentation detoxification methods. The untreated CSC had 0.19mg/Kg free gossypol and total gossypol of 1.35mg/Kg. It was concluded that 1g iron sulphate/Kg CSC and 48 hours fermentation treatments will be necessary before inclusion of CSC into the diets of *Clarias gariepinus* fingerlings.

KEYWORDS: Detoxification, Cotton seed cake, Soybean meal, fermentation, iron sulphate, *Clarias gariepinus*

INTRODUCTION

Feed generally represent the largest cost in fish production. Highest proportion of protein in fish feeds have commonly be represented with fishmeal however due to scarcity and high cost, alternative plant proteins such as soybean and groundnut cake have been exploited to reduce the quantity of fishmeal in fish diets. However, even these conventional plant proteins today are highly expensive due to pressure of use. FAO (2009) reported an immediate requirement to find an alternative protein supplement due to increase in demand and high costs of conventional protein ingredients such as fishmeal, soybean meal and groundnut cake. The presence of toxic effect and antinutritional factors limit the use of plant substitutes in fish feeds (Francis *et al.*, 2001; Lee *et al.*, 2006). Gossypol is yellow polyphenolic compounds found in the pigment gland of whole cottonseed plant (genus *Gossypium*). Being toxic, gossypol imparts insect resistance to cotton, making low-gossypol varieties subject to considerable damage by insect attack. Some gossypol is bound to protein in the stomach contents of ruminants when it consumes cottonseed meal or cake. Cottonseed cake (CSC) remains after oil is extracted from the seeds which could be exploited in fish feeds. During processing the seeds are sliced into flakes to facilitate extraction of oil for use in salad oil, margarine and shortening. The remaining cottonseed flakes, together with some free gossypol, are ground into cottonseed meal for use as a protein supplement for livestock.



Attempts to produce glandless cottonseeds or genetically engineer gossypol out of those plants have not yet been entirely successful. Removing gossypol from the growing plant increases vulnerability to insects and other diseases; thus, gossypol is also referred to as a naturally occurring insecticide.

Gossypol binds some amino acids, particularly lysine and methionine, leading to protein malnutrition and poor growth rate. In male ruminants, gossypol damages the spermatogenic epithelium, inhibits enzymes in Leydig cells that are required for steroid synthesis. Gossypol can cause systemic and reproductive disease syndromes, depending on the species of exposed animal and the dosage of free gossypol consumed (Randel *et al.*, 1992). The toxic effects of gossypol are cumulative and systemic disease, characterized by hepatic, renal, cardiovascular and pulmonary abnormalities generally observed in monogastric animals. From the foregoing it became necessary to detoxify cotton seed cake to make it safe for use in fish feed since it has a crude protein level relatively close to soybean meal and groundnut cake, it could be used to replace either. However soybean meal was the target of this study.

MATERIALS AND METHODS

Dietary Treatments: Treatment one (1) devoid of any form of CSC served as control while the untreated CSC served as treatment two (2). Two levels (1000mg and 1500mg) of Iron sulphate (Fe_2SO_4)/Kg CSC treatment was carried out to form treatment three (3) and four (4) as Fe is known to bind to the active site of the gossypol molecule and render it harmless to the consumer. Fermentation was used in this study to treat CSC with length of fermentation period forming two treatments viz 48 hours and 72 hours, treatment five (5) and six (6) respectively. Diets 1 – 6 were formulated with other ingredients and CSC. The different form of treated CSC was used to replace 20% of the soybean meal in the control diet formulated with basal diet and 25% soybean meal (SBM). The basal diet composed of 20% clupeid meal, GNC, wheat offal, starch, vegetable oil and micro ingredients.

Experimentation: Completely randomized design was used to carry out the 42 days study. The experimental fish were stocked in triplicate groups in a 2 X 2 X 1m³ experimental tanks with 40 fingerlings per replicate. The *Clarias gariepinus* fingerlings were obtained from NIFFR hatchery and acclimatized for 2weeks during which they were fed the control diets to adjust to the experimental environment. After acclimatization all

the treatments were fed to each replicate group at 5% body weight. The ration per day was divided into 2 and supplied to the fish morning (8.00-9.00 am) and evening (6.00-7.00 pm). Fortnight sampling was carried out to assess fish health status, growth performance and weight obtained used to adjust feeding rate. At the end of six weeks final sampling was carried out and blood was collected from six randomly selected juveniles per replicate group and the carcass were used for whole body proximate analysis.

Data Analysis: The data obtained were subjected to Analysis of variance (ANOVA) using SPSS version 15.0 software (SPSS Inc., Chicago, IL, USA). Where significant difference was observed means were separated with Duncan multiple range test with level of significance set at statistical values of $P < 0.05$.

Table 1: Composition of 40% Crude Protein Experimental Diet with 20% SBM replaced by Untreated and Modified Cottonseed Cake.

Ingredients	Diets					
	1 Control	2 Untreated CSC	3 1gFe/Kg CSC	4 1.5gFe/Kg CSC	5 48HrsFerm CSC	6 72HrsFerm CSC
Cottonseed Cake (CSC)	0.00	20.00	20.00	20.00	20.00	20.00
SBM	25.00	5.00	5.00	5.00	5.00	5.00
Basal	75.00	75.00	75.00	75.00	75.00	75.00

RESULTS AND DISCUSSIONS

The results of growth performance of the fish are presented in table 2 below. The initial weight and average survival showed no significant difference ($P > 0.05$) while there were significant differences in weight gain and all other parameters. The group that fed on iron (Fe) treated cottonseed cake had significantly ($P < 0.05$) higher weight gain and best feed conversion ratio (FCR) compared to the group that fed on fermented, untreated cottonseed cake (CSC) and even the control. (Table 2). The total length and standard length also showed significant variation ($P < 0.05$). These results agree with those of Yildirim *et al.* (2003) who reported a reduction of gossypol toxicity with the addition of iron. Growth was not low in this study as against the observation of Mbahinzireki *et al.* (2001) who reported low growth in all dietary groups. In this present study soybean meal was replaced by CSC and better performance than previous studies was observed (Mbahinzireke *et al.*, 2001; Yildirim *et al.*, 2003; Rinchard *et al.*, 2003a and El-Saidy and Garber, 2004). Plates 1 to 4 represents the fish fed diets with differently treated CSC. The fish that fed on the diets with untreated CSC had very dark skin colouration compared to fish from other treatments.

The packed cell volume and haemoglobin levels were significantly better in the groups that fed on the control diet and that with 1g iron sulphate treated CSC ($P < 0.05$) while these parameters were significantly lower in the groups that fed on fermented and untreated CSC ($P < 0.05$). The higher Fe treated group seems to have compensation from the excess iron for hematopoiesis hence the higher Hb observed in the group that fed on the treatment. Indicating that the 1000mg Fe_2SO_4 seems adequate to treat a kilogramme of CSC for good performance of *Clarias* though the earlier reports by Meric *et al.* (2011) iron compensation effect was beneficial at 30% level of supplementation but not at 45% level with tilapia when 900 and 1350 mg Fe/Kg CSC were used. The whole body proximate composition showed significant difference between treatments ($P < 0.05$; Table 2). The moisture was significantly higher in the group that fed on diet with 72 hours fermented CSC ($P < 0.05$) which was not significantly different from the control group ($P > 0.05$). The percentage dry matter, crude protein and nitrogen free extract (NFE) were significantly higher in the group that fed on diets with CSC treated with iron ($P < 0.05$). The whole body composition was not far from *Clarias* of other studies hence the overlap of all treatment's performance (Solomon *et al.*, 2018; Ibiyo *et al.*, 2020).

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The gossypol analysis showed that the free and total gossypol content were in the range of 0.075 – 0.09mg/Kg and 0.6 - 0.75mg/Kg respectively for the iron and fermentation detoxification methods. The untreated CSC had 0.19mg/Kg free gossypol and total gossypol of 1.35mg/Kg.

In conclusion, cotton seed cake could be used to replace up to 20% soybean meal in the diet of *Clarias gariepinus*. For good performance of the fish 1000mg (ie 1g) Fe₂SO₄/kg CSC will be necessary or 48 hours fermentation of the CSC before use because at longer period of fermentation unidentified substances were formed as revealed by the chemical analysis which might have affected performance of the group that fed on diet with 72 hours fermented CSC. Further study is needed to ascertain its influence on the broodstock performance by using the CSC diets to grow the fish to sexual maturity and other species.



Plate 1: Fish fed Control Diet



Plate 2: Fish fed Untreated CSC diet



3: Fish fed Iron Treated CSC diets



Plate

Plate 4: Fish fed diets with Fermented CSC

Table 2: Growth Performance of *Clarias gariepinus* fingerlings fed Differently Modified Cottonseed Cake (0 – 6 weeks).

Means in row with different superscripts significantly differ ($P < 0.05$).

Parameters	1 Control	2 Untreated CSC	3 1gFe/Kg CSC	4 1.5gFe/Kg CSC	5 48HrsFerm CSC	6 72HrsFerm CSC
Av. Survival	34.33±4.5	34.00±5.6	32.00±2.0	36.00±3.0	30.00±0.57	33.00±0.0
Initial Weight (g/Fish)	2.60±0.39	2.97±0.03	3.00±0.79	3.33±0.28	3.7±0.86	2.82±0.05
Weight Gain (g/Fish)	11.84±1.9 ^b	8.53±0.45 ^b	22.17±10.08 ^a	23.32±5.6 ^a	10.84±0.12 ^b	11.78±0.15 ^b
Feed Intake (g/Fish)	10.13±1.68 ^b	9.83±1.35 ^b	8.03±3.43 ^b	15.37±0.68 ^a	8.83±0.40 ^b	10.27±0.0 ^b
FCR	0.85±0.006 ^b	1.16±0.21 ^c	0.36±0.01 ^a	0.68±0.14 ^b	0.81±0.02 ^b	0.87±0.01 ^b
SGR (%)	4.07±0.03 ^b	2.94±0.49 ^c	5.2±0.66 ^a	4.91±0.36 ^a	3.90±0.55 ^b	3.91±0.02 ^b
Total Length	14.7±4.24 ^{ab}	12.13±2.09 ^{ab}	12.05±2.55 ^b	14.0±1.75 ^{ab}	13.44±0.68 ^{ab}	17.37±1.97 ^a
Standard Length	13.15±3.84 ^{ab}	10.75±1.95 ^b	11.02±2.68 ^b	13.25±1.2 ^{ab}	12.17±0.58 ^{ab}	16.05±2.15 ^a
Packed Cell Volume	38.13±0.31 ^a	24.3±0.62 ^b	36.87±1.3 ^a	37.83±0.93 ^a	26.47±2.12 ^b	26.27±0.80 ^b
Haemoglobin	17.57±1.19 ^a	9.20±0.87 ^c	17.67±1.13 ^a	18.03±0.70 ^a	11.11±0.96 ^{cb}	12.33±1.9 ^b
Whole Body composition						
Moisture %	71.33±1.5bcd	72.56±1.06cd	68.92±1.01a	69.61±1.0a	71.00±0.57bcd	73.00±0.06d
Crude Protein %	19.45±0.19ab	17.77±0.03ed	20.12±0.12a	19.33±0.28b	18.7±0.86bc	18.23±0.05dc
Crude Fat %	1.84±0.2 ^a	2.13±0.15 ^c	1.17±0.12 ^a	1.32±0.2 ^a	1.84±0.17 ^b	1.78±0.15 ^b
Crude Fibre	1.13±0.18 ^a	1.3±0.35 ^a	1.43±0.23 ^a	1.37±0.18 ^a	1.43±0.40 ^a	1.27±0.0 ^a
NFE %	6.25±1.14 ^b	6.24±1.04 ^{bc}	8.76±0.01 ^a	8.37±0.14 ^a	7.03±0.02 ^b	5.72±0.01 ^c
DM %	28.67±1.5b	27.44±1.06cd	31.08±1.01a	30.39±1.0ba	29.0±.57b	27.03±.06d

Av. = Average; FCR = Feed Conversion Ratio; SGR = Specific Growth Rate; W/ = Whole, NFE= Nitrogen free Extract

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9

NUTRITIONAL AND PHYTOCHEMICAL COMPOSITION OF SWEET POTATO (*Ipomoea batatas*) AND YAM (*Dioscorea spp*) LEAF MEAL FOR AQUACULTURE FEEDS

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ABSTRACT

The nutrient and anti-nutrient composition of some standardized sweet potato (*Ipomoea batatas*) and Yam (*Dioscorea spp*) leaves were conducted at JAJEE Laboratory, University of Ibadan, Nigeria. The result of the proximate analysis shows that the moisture contents of sweet potato leaf meal have $12.10 \pm 0.21\%$ and Yam leaf meal contained $12.00 \pm 0.10\%$. There were no significant differences ($P < 0.05$) for moisture contents of the leaves meal. The crude protein of sweet potato leaf meal has $14.01 \pm 0.12\%$ and the Yam leaf meal contained $18.92 \pm 0.20\%$, there were significant differences ($P > 0.05$) for the crude protein of the leaves meal. The crude fat of sweet potato leaf meal has $2.06 \pm 0.41\%$ and the Yam leaf meal contained $4.36 \pm 0.60\%$, there were significant differences ($P > 0.05$) for crude fat of the leaves meal. There were cleared

significant differences among the two leaves meals analyzed of fiber ($20.47 \pm 0.70\%$), ash ($8.73 \pm 1.12\%$), and carbohydrate ($42.63 \pm 0.91\%$) for sweet potato leaf meal while fiber ($12.78 \pm 0.80\%$), ash ($15.42 \pm 1.21\%$) and carbohydrate ($36.52 \pm 0.88\%$) for Yam leaf meal. The mineral analysis shows that there were no cleared trends among the two leaves meal, but contained higher significantly different ($P > 0.05$). The results of phytochemical composition that, the leaves quantitatively of tannins ($2598.97 \pm 1.12\text{mg}/100\text{g}$), phytate ($0.39 \pm 0.10\text{mg}/100\text{g}$), trypsin inhibitor ($5.55 \pm 0.39\text{mg}/100\text{g}$), total phenol ($7927.13 \pm 1.49\text{mg}/100\text{g}$), alkaloids ($1.86 \pm 1.70\%$), oxalate ($100.65\text{mg}/100\text{g}$), Saponins ($0.0078 \pm 0.22\%$) and carotenoids ($18.79 \pm 0.17\text{mg}/100\text{g}$) for sweet potato leaf meal, and tannins (3820.37 ± 1.33), phytate ($1.32 \pm 1.40\text{mg}/100\text{g}$), trypsin inhibitor ($10.91 \pm 0.41\text{mg}/100\text{g}$), total phenol ($7547.70 \pm 1.14\text{mg}/100\text{g}$), alkaloids ($4.03 \pm 1.11\%$), oxalate ($82.09 \pm 0.35\text{mg}/100\text{g}$), Saponins ($0.0092 \pm 0.09\%$) and carotenoids ($8.75 \pm 0.19\text{mg}/100\text{g}$) for Yam leaf meal. There were no significant among the two leaves analysed and it was concluded that the leaves are plant protein sourced and contained anti-nutrients. There by the research is recommended that further investigation on the utilization of these leaves meal for aquaculture feeds; appropriate processing methods and potent means of removing the anti-nutritional factors should be carried out.

Keywords: Phytochemical, Nutritional values, minerals, leaf meal

INTRODUCTION

Good nutrition in an animal production system is to economically produce a healthy high-quality product (Abubakar *et al.*, 2013). In fish farming, nutrition is critical because feed represents 60-80% of the production cost (Abubakar *et al.*, 2013). Fish nutrition has advanced dramatically in recent years with the development of new, balanced diets that promotes optimal fish growth and health (Abubakar *et al.*, 2013). The development of new species-specific formulations supports the fish farming industry as it expands to satisfy the easing demand for affordable, safe, and high-quality fish and seafood products (Abubakar *et al.*, 2013). Nigerian feedstuffs have been in ton decline in recent years because of the diminishing output of certain traditional crops (FAO, 2011). Recent statistics demonstrated that Nigeria relies on imports to meet the increase in the price of food and feed resources in the country which aggravated the high cost of fish feed which has been a major problem for fish farmers in Nigeria (FAO, 2011).

The use of plants or plant-derived feedstuffs such as legume seeds, different types of oilseed cake, leaf meal, and vegetable leaf protein concentrates as fish feed ingredients is limited by the presence of a wide variety of anti-nutritional substances (Francis *et al.*, 2001). The effects of these substances on fish include reduced palatability, the altered nutrient balance of the diet, disturbance of digestive processes and growth, decreased feed efficiency, pancreatic hypertrophy, hypoglycemia, liver dysfunction, osteogenesis, and immune suppression (National Research Council, 2011; Krogdahl *et al.*, 2010). Several anti-nutritional compounds are present in animal feed ingredients. Tannins are secondary compounds present in plants and comprise polyphenols of great diversity (Hoste *et al.*, 2006). The physical and chemical properties of tannins vary between plants, in different plant parts, and between plants, in different plant parts, and between seasons (Waghorn *et al.*, 1990). At high levels (above 50 g/kg DM), tannins in plant material can become an anti-nutritional factor and can result in reduced feed intake and digestibility in animals (Barry and McNabb, 1999). It has been observed that common processing techniques, such as cooking, soaking, drying, and wet heating, as well as adding feed supplements, can reduce the concentration of ant-nutritional factors in plant feeds and improve the feed intake (Rehman and Shah, 2005; Francis *et al.*, 2001; Alonso *et al.*, 2000).

The sweet potato (*Ipomoea batatas*) and Yam (*Dioscorea spp*) leaves came to mind as being a traditional tuber crop adaptable to a wide ecological range, relatively short growing season, and, of high yield potential even on infertile soil (Hahn, 1984). The leaves also came to mind because of its nutrient composition which helps to elevate the midst of the nutritional problems of the individual. To achieve the expected success in the creating awareness for sweet potato, the nutritional composition of the leaves must be known by the

people. This study aims to assess the nutrient composition, mineral content, and phytochemical composition of sweet potato (*Ipomoea batatas*) and Yam (*Dioscorea spp*) meals for fish feed.

Materials and Methods

Experimental Site

The phytochemical, Proximate, and mineral analysis of Sweet potato and Yam leaves meal were conducted at JAJEE Laboratory, University of Ibadan, Nigeria.

Procurement and processing of the leaves meal

The leaves were cultivated at IITA, Ibadan. The plant leaves were plucked from the stem and were thoroughly washed with water to remove dirt, drained properly, and later shade-dried at room temperature at the fish nutrition Laboratory, Biotechnology department, NIOMR for three weeks (21 days). The leaves were blended into a fine powder using Blender (model /number: Trublend 2.2 AQ) and sieved using 1.18mm laboratory sieve to remove the residues. The fine particles were used for phytochemical, proximate and mineral composition analysis.

Proximate and minerals composition

Samples of the leaves meal were used for proximate and minerals analysis according to the procedure of the Association of official analytical chemists (AOAC, 2000). The parameters analysed were; moisture, Crude protein, fiber, lipid, Ash, and carbohydrate while for the mineral; Ca, Mg, K, Na, Mn, Fe, Cu, Zn, P, Cobalt, Cr, Cd, Pb, and Nickel

Phytochemical Analysis of the leaves meal

The phytochemical constituents were conducted based on the aqueous extracts of the leaves to determine the quantitative tests, the constituents were; tannins, phytate, trypsin inhibitor, total phenol, alkaloids, oxalate, Saponins, and carotenoids using standard protocols (Sofwora, 1982; Trease and Evans, 1993).

Statistical analysis

Data obtained were subjected to analysis of variance (ANOVA) and, the treatment means were separated for significant differences using procedure of Duncan's Multiple Range Test (Steel and Torrie, 1980). All the analyses were carried out using the computer software Statistical Package for the Social Sciences Version 2.0.

RESULTS AND DISCUSSION

The results of the proximate analysis of the leave samples are shown in Table 1. The result of the proximate analysis shows that the moisture contents of sweet potato leaf meal have $12.10 \pm 0.21\%$ and Yam leaf meal contained $12.00 \pm 0.10\%$. There were no significant differences ($P < 0.05$) for moisture contents of the leaves meal. These values were higher than that reported by Jibrin *et al.* (2018) who analyzed *cassia Tora* leaf meal of the value ($3.45 \pm 0.5\%$). This variation might have been a result of the shorter duration during the processing of the leaves meal (Kubmarawa *et al.*, 2011). The crude protein of sweet potato leaf meal has $14.01 \pm 0.12\%$ and the Yam leaf meal contained $18.92 \pm 0.20\%$, there were significant differences ($P > 0.05$) for the crude protein of the leaves meal. The value of crude protein was lower than those obtained by Jibrin *et al.* (2018) who analyzed *cassia Tora* leaf meal values ($28.52 \pm 0.52\%$). The variations in proximate compositions with the other study may be due to environmental factors such as soil types, season, geographical location, provenances, harvesting time, and stage of maturity (Kubmarawa *et al.*, 2011).

The crude fat of sweet potato leaf meal has $2.06 \pm 0.41\%$ and the Yam leaf meal contained $4.36 \pm 0.60\%$, there were significant differences ($P > 0.05$) for crude fat of the leaf meal. These values contradicted the findings by Jibrin *et al.* (2018) who reported a higher value of crude fat; this could be might due to different processing technics and the duration of the drying during the processing.

There were cleared significant differences among the two leaves meals analyzed of fiber ($20.47 \pm 0.70\%$), ash ($8.73 \pm 1.12\%$), and carbohydrate ($42.63 \pm 0.91\%$) for sweet potato leaf meal while fiber ($12.78 \pm 0.80\%$), ash ($15.42 \pm 1.21\%$) and carbohydrate ($36.52 \pm 0.88\%$) for Yam leaf meal. The crude fiber obtained in this study

was higher than the findings by (Kubmarawa *et al.*, 2011; Jibrin *et al.*, 2018). The ash level ($15.42 \pm 1.21\%$) of the Yam leaf meal also compared well with some non-conventional feedstuffs such as *Celtis integrifolia* leaf meal with an ash level of 13.53% (Kubmarawa *et al.*, 2011).

Results of the elemental analysis showed the leaves contain the following minerals; Ca, Mg, K, Na, Mn, Fe, Cu, Zn, P, Cr, Cd, Pb, and Nickel. The highest mineral recorded was Ca of the value $12226.90 \pm 1.64\text{mg}/100\text{g}$ for sweet potato leaf meal which was a significant difference ($P > 0.05$) from the entire elements analyzed. This value was higher than that obtained by (Kubmarawa *et al.*, 2011). It was also higher than was obtained in some common Nigerian vegetables reported by Aletor and Adeogun 1995; *Basellatubra* leaves ($5.80\text{g}/100\text{g}$) and *Maranthus hybridus* leaves ($4.2\text{g}/100\text{g}$). Calcium is an important dietary mineral for strong bones and muscle/neurological function (Iffon and Bassir, 2000). The lowest mineral element was recorded in Cr of $0.24 \pm 1.12\text{mg}/100\text{g}$ for sweet potato leaf meal and Nickel of $0.24 \pm 0.01\text{mg}/100\text{g}$ for Yam leaf meal. These values were lower than those for some common vegetables; *Telferia occidentalis* leaves ($0.65\text{g}/100\text{g}$), *Chochorusolitoris* leaves ($0.59\text{g}/100\text{g}$), and *Amaranthus hybridus* leaves ($0.59\text{g}/100\text{g}$) reported by Iffon and Bassir (2000).

The results of phytochemical and anti-nutrient compositions (Table 3) revealed the presence of tannins, phytate, trypsin inhibitor, total phenol, alkaloids, oxalate, Saponins, and carotenoids. These phytochemicals exhibit diverse pharmacological and biochemical actions when ingested by animals (Amadi *et al.*, 2006). The highest phytochemical constituents were recorded in total phenol of $7927.13 \pm 1.49\text{mg}/100\text{g}$ for sweet potato leaf meal and $7547.70 \pm 1.14\text{mg}/100\text{g}$ for Yam leaf meal. These values were higher than that obtained by Jibrin *et al.* (2018). The least phytochemical constituents were recorded in Saponins of the value ($0.0078 \pm 0.22\%$) of sweet potato leaf meal and ($0.0092 \pm 0.09\%$) of Yam leaf meal. These values were lower than that obtained by Jibrin *et al.* (2018) and Nwankwo (2014).

Saponins reduce the uptake of certain nutrients including glucose and cholesterol in the gut through intra-luminal physicochemical interactions (Nwankwo 2014). Hence, it has been reported to have a hypocholesterolemic effect (Price *et al.*, 1987) and thus may aid in lessening the metabolic burden that would have been placed on the liver. It was observed that from this study saponins recorded lower values in both the two leaves meal. Alkaloids recorded $1.86 \pm 1.70\%$ of sweet potato leaf and $4.03 \pm 1.11\%$ of Yam leaf meal. These findings were not in line with the finding by Nwankwo (2014).

Alkaloids are often toxic to man and may have dramatic physiological activities hence their wide use in medicine (Shelton, 2000), while flavonoids reduce oxidative damage that can lead to thrombosis and blockage of coronary arteries (Kitts, 1994). The tannins content of $2598.97 \pm 1.12\text{mg}/100\text{g}$ of sweet potato leaf and $3820.33 \pm 1.33\text{mg}/100\text{g}$ were higher than the recommended 0.15 -0.20% for the dietary animal (Schiavono *et al.*, 2007). Tannins are capable of lowering available protein by antagonistic competition and can, therefore, elicit protein deficiency syndrome, 'kwashiorkor' (Maynard, 1997). These anti-nutritional factors can easily be reduced to tolerable limits by proper simple processing techniques such as soaking cooking, frying, and g (Ekpo *et al.*, 2004; Ekpo and Eddy, 2005).

Table 1: Proximate composition of Sample leaves meal

Parameters	Sweet potato leaf meal	Yam leaf meal
Moisture (%)	12.10 ± 0.21^a	12.00 ± 0.10^a
Protein (%)	14.01 ± 0.12^b	18.92 ± 0.20^a
Lipid (%)	2.06 ± 0.41^b	4.36 ± 0.60^a
Fiber (%)	20.47 ± 0.70^a	12.78 ± 0.80^b
Ash (%)	8.73 ± 1.12^b	15.42 ± 1.21^a
Carbohydrate (%)	42.63 ± 0.91^a	36.52 ± 0.88^b
Digestibility (%)	59.59 ± 0.00^a	59.59 ± 0.00^a
M.E (kcal/kg)	2157.13 ± 0.00^b	7547.70 ± 0.00^a

Means with different super superscripts along the row indicate significant ($P>0.05$) difference

Key: ME Metabolizable energy

Table 2: Mineral composition of Sample leaves meal

Parameters	Sweet potato leaf meal	Yam leaf meal
Ca (mg/100g)	12226.90±1.64 ^a	19.97±1.12 ^b
Mg (mg/100g)	240.44±1.50 ^a	223.92±1.10 ^b
K (mg/100g)	682.09±1.00 ^a	3240.28±0.90 ^b
Na (mg/100g)	103.89±0.81 ^b	231.66±0.5 ^a
Mn (mg/100g)	40.61±1.2 ^a	9.23±0.89 ^b
Fe (mg/100g)	16.64±1.30 ^b	83.14±1.40 ^a
Cu (mg/100g)	0.97±0.70 ^a	0.73±0.11 ^a
Zn (mg/100g)	3.16±0.11 ^a	3.42±0.22 ^a
P (mg/100g)	59.27±1.00 ^b	316.33±1.44 ^a
Cobalt (mg/100g)	0.00±0.00 ^a	0.00±0.00 ^a
Cr (mg/100g)	0.24±1.12 ^a	0.68±0.01 ^a
Cd (mg/100g)	0.003±0.01 ^a	0.002±0.01 ^a
Pb (mg/100g)	0.00±0.00 ^a	0.00±0.00 ^a
Nikel (mg/100g)	0.37±0.02 ^a	0.24±0.01 ^a

Means with different superscripts along the row indicate a significant ($P>0.05$) difference

Table 3: Phytochemical composition of Sample leaves meal

Parameters	Sweet potato leaf meal	Yam leaf meal
Tannins (mg/100g)	2598.97±1.12 ^b	3820.33±1.33 ^a
Phytate (mg/100g)	0.39±0.09 ^b	1.32±0.01 ^a
Trypsin inhibitor (TIU/mg)	5.55±0.39 ^b	10.91±0.41 ^a
Total phenol (mg/100g)	7927.13±1.49 ^a	7547.70±1.14 ^b
Alkaloids (%)	1.86±0.07 ^b	4.03±0.11 ^a
Oxalate (mg/100g)	100.65±1.00 ^a	82.09±0.35 ^b
Saponins (%)	0.0078±0.00 ^b	0.0092±0.00 ^a
Carotenoids (mg/100g)	18.79±0.07 ^a	8.75±0.09 ^b

Means with different superscripts along the row indicate a significant ($P>0.05$) difference

CONCLUSION AND RECOMMENDATION

The result concluded that sweet potato and Yam leaves meal contained nutritive values and phytochemical constituents. It could be used as a protein supplement in fish feed formulation, the leaves were also relatively high in mineral elements. The findings in the present study recommend further investigation on the awareness and the utilization of sweet potato and Yam leaves meal in fish feed.

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INFLUENCE OF POWDERED PAWPAP SEED MEAL (PPSM) ON MASCULINIZATION OF *Oreochromis niloticus* USING SQUASH METHOD

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ABSTRACTS

The research was carried out to examine the influence of different inclusion levels of powdered pawpaw seeds on the masculinization of *Oreochromis niloticus*. Three hundred fry each weighed 0.012g and length 1.0cm were fed D₁ 0g/kg, D₂ 0.3g/kg, D₃ 0.5g/kg, D₄ 0.9g/kg and D₅ 1.2g/kg for 70 days in plastic bowls (30 Litres). Each treatment (20 hatchlings) was in triplicates in complete randomised design (CRD). The results showed that gonads from the fingerlings were easily differentiated into males and females using Aceto-Carmine method, mounted under Compound Microscope using magnification of 60 to 100. The male gonads were differentiated by fine granular-like structure of spermatogonial and the female gonads were characterized by having a structure with previtellogenic oocytes. The percentage male fish was highest D₃ (100%) and D₄ (100%), followed by D₅ and D₂ (80%) respectively and D₁ (25%). From the results, it could be concluded that all the treatments with the exception of the control (D₁) gave high percentage of males. However, D₃ and D₄ performance were the best.

KEYWORDS: Pawpaw seeds, masculinisation, squash method, *Oreochromis niloticus*

INTRODUCTION

Tilapia farming is almost taking over the farming of other fish species today in some African countries (Ragasa *et al.*, 2022; Christopher *et al.*, 2021) because of its low protein requirement, short culture period, fast growth of the males and consumer preference, wide range of adaptability to different environmental conditions and ability to reproduce in captivity (Wokeh and Orose, 2021; Ajuzieogu *et al.* 2021). Generally, female Tilapia reproduce in captivity prolifically even at a very small size, leading to overpopulation of the culture system and stunted growth. This therefore calls for production of masculinized tilapia that will enhance better growth and earnings of more profits. The most common methods of masculinisation of Tilapia for commercial production is the application of hormones using 17 α -methyl testosterone (Celik *et al.*, 2011). This method is not without its attendant negative effects on the consumers (Kefi *et al.*, 2012). Notwithstanding the limited availability, cost and permitted usage in many countries because of the environmental effects. These unhealthy effects have necessitated alternative methods for the masculinisation of Tilapia such as use of plant extracts (Mukherjee *et al.*, 2018; Alok *et al.*, 2013) seeds and leaves (Ugonna *et al.*, 2018), hybridization (Snake *et al.*, 2020) and immersion in honey (Heriyati *et al.*, 2015; Abdullah, 2018; Onyia *et al.*, 2022).

Pawpaw seeds contain phytochemicals that have attracted many scientists to work on using it for masculinisation of *Oreochromis niloticus* in order to control the prolific reproduction of the female and stunted growth of the fingerlings (Ampofo-Yeboah, 2013). The objectives of the study are to examine the influence of PPSM on the ratio of males and females larvae using squash method.

MATERIAL AND METHODS

Study Area and Source of fry: The research was carried out in the Department of Fisheries Teaching and Research wet laboratory, Modibbo Adama University Yola, Adamawa State. Three-day old fry were collected from nursery pond and taken to the wet laboratory, where they were acclimatized for three days. Twenty fry each were randomly selected and stocked in fifteen plastic bowls (50L) and fed according to the required treatments designated D1 (control, no PPSM), D2, D3, D4, D5.

Masculinization treatment and control

Ripe Pawpaw fruits were purchased from Jimeta Market Yola, the seeds were removed and dried at room temperature. The seeds were then ground and sieved. The powdered seed was added to the basal feed (35% CP) at different inclusion levels of D1 0g/Kg, D2 0.3g/kg, D3 0.5g/kg, D4 0.9g/kg and D5 1.2g/kg. The Fry were fed thrice per day at 10% BW.

Sex Determination

At the end of the research, ten fish were randomly selected from each treatment group as well as the control and were sacrificed. Sex ratio in each treatment was determined by microscopic examination of gonad tissue using standard Aceto-carmine squash technique (Guerrero and Shelton, 1974).

Data Analysis

Data collected on the frequency of male and female was noted. The ratios of the sex were determined by percentages.

RESULTS and DISCUSSION

Sexing of fingerlings

Fish gonads from the fingerlings were easily differentiated into males and females using Aceto-Carmine method, mounted under Compound Microscope using magnification of 60 to 100. The male gonads were differentiated by fine granular-like structure of spermatogonia (Plate 2) and the female gonads were characterized by having a structure with previtellogenic oocytes (Plate 1).

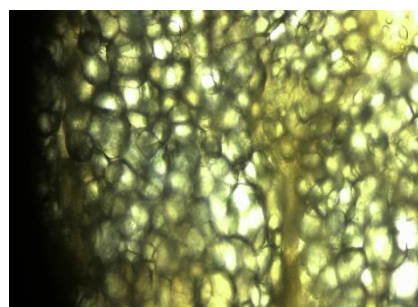
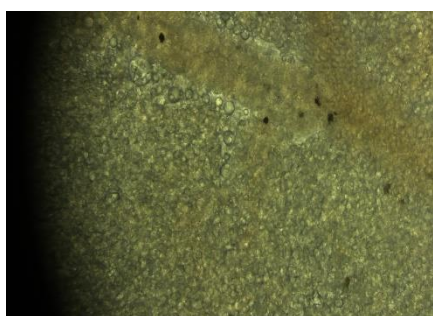


Plate 1: Female gonad of *O. niloticus* x100 Plate 2 Male gonad *O. niloticus* x100

Sex Ratios of fry fed different inclusion levels of PPSM

Ten fingerlings were randomly collected from each treatment and the control, using Aceto-Carmine techniques the ratios were determined (Table 1). The results showed that D3 and D4 had 100% males, while D2 and D5 had 80% males and 20% females respectively. On the other hand D1 (Control) had 25% males and 75% females.

Table 1: Percentage Masculinisation *Oreochromis niloticus* fed PPSM

Treatments	Percentage	Male	Percentage	Female

D1	25.00	75.00
D2	80.00	20.00
D3	100.00	0.00
D4	100.00	0.00
D5	80.00	20.00

The use of Aceto-Carmine technique was successful in sexing the fingerlings of *Oreochromis niloticus*. The sexing of small fish have been a major challenge to fish Biologist because of immature gonads(Guerrero and Shelton,1974). Aceto-Carmine technique according to the authors was used to characterized the sex of larvae and fingerlings. Wassermann and Afonso (2002) validated the used of Aceto-carmine method to sex *O. niloticus* juveniles. The descriptions of the gonads of males and females in this study agree with that of Wassermann and Afonso (2002); where the male gonads had fine and smooth granular like structures showing testicular tubes; while the females had a round shape with previtellogenic oocytes.

A high percentage of males recorded in this research agree with Omeji 2016, who reported 77.8% male *Oreochromis mossambicus* fry fed pawpaw seed powder. It was reported also that pawpaw seeds can control reproduction by triggering temporary infertility and irregular oestrous cycle which is reversible when the treatment is withdrawn(Bhatti *et al.*, 2021). The same authors reported that sterility is evident by high dosage of pawpaw seeds believed to be toxic due to the presence of the enzyme papain and some active ingredients reported to cause sterility in rats and control prolific reproduction in *Oreochromis niloticus*. This could be the reason for high production of male fish in this study. Nkeiruka and Chinaka 2013, reported that pawpaw seed may be effective as sterility-inducing agents at higher dosage as they disintegrate the testes and ovaries resulting in the devoid of spermatids and oocytes respectively.

CONCLUSION From the results of this research 0.5g/kg and 0.9g/kg PPSM gave the highest percentage male *O. niloticus* and therefore, either quantity of PPSM is recommended for the production of male *O. niloticus*.

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COMPARATIVE STUDY OF GROWTH PERFORMANCE OF AFRICAN CATFISH, *Clarias gariepinus*: FINGERLINGS REARED IN CAGE, CONCRETE POND AND EARTHEN POND SYSTEMS IN OTAMIRI RIVER AREA, UMUAGWO, IMO STATE, NIGERIA.

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ABSTRACT

A study of the comparison between cage fish farming and pond culture system was conducted between 1ST of March and August 31^S, 2019, a period of 184 days. Predator barrier net was constructed with galvanized angle rod and ½ copper wire mesh. Fish net cage constructed with ½ netting materials (210 D/9), nylon twine (210 D/9 and 210 D/8) and ropes (10mm PE and 4mm PE, as house in which the fish fingerlings were stocked. The stocked fish were held captive in the fish net cage while water flows through it. This is Treatment 1 (T_i). A concrete pond of 10m x 10mx 15m was constructed, as Treatment II (T₁₁). Simultaneously an earthen pond measuring 10m x 10mx 15m was constructed entirely from soil materials both manually and mechanically in a site with excess water retention potential near Otamiri river besides the Fisheries Department of the University of Agriculture. This is Treatment III (T₁₁₁). Each of the treatments were stocked with 1,500 *Clarias* fingerlings of 10gms average weight and managed simultaneously for the 6-month period. Data were analysed by simple descriptive statistics. The result showed 83.3%, 93.3% and 96.7% survival rate in cage, concrete pond and earthen pond system. Average weight at harvest (gm) and total weight at harvest (gm) of 332.6 gm and 415.7gm for cage fish farming, 250.6gm and 350.8gm for concrete pond system and 250.6gm and 280.65gm for earthen pond system. The survival rate in cage culture (83.3%) was low due to high water depth, as cage was floated, hence fingerlings could not maximize feed intake at the initial stage. The 96.7% suggest that the earthen point system has the highest production rate. Adequate care should be taken to ensure maximal utilization of feed given to the fish in cage floater in water.

Keywords: Fish farming, Survival rate, Predator barrier/protection net, Stocking.

INTRODUCTION

Fisheries sub-sector has been playing a very economic and significant role in the development of agricultural based economic as a focal point for Nigerian Government effort for a diversified economy. Ozigbo *et.al*,(2014) citing FDF (2008) articulated the fisheries development and showed that fisheries sub-sector projected a contribution of only 2.5% of national GDP in 2015. The authors also showed that fish supply within the period was 671.492t whereas demand was 2,650.000t, leaving a deficit of 1,978.500t. Ozigbo *et.al*,(2014) present a critical review of fisheries and aquaculture production and management in Nigeria and show that it is essential to follow improved agricultural management practices to ensure enhanced yield. Aquaculture is a major fish farming strategy, becoming very popular and a major source of accelerated fish production. Fečkaninová *et. al.* (2017) explain that fish-farming in ponds is a fast developing food producing sector in the world, and a major source of food security. Orose *et.al*.(2018) quoting Tansy and Worsley

(2014) explain that with the increasing human population, urbanization and increase in demand for fish, improvement in all methods of accelerated fish production cannot be over-emphasized. Ochang *et al.* (2014) reported that the farming of African catfish *Clarias gariepinus* has become popular in Africa, and quoting Adewolu *et al.* (2018) explained that this popularity is attributable to the catfish's rapid growth, disease resistance, hardiness, excellent taste and high market demand. In the same vein, Deines *et al.* (2014) explained that the Nile *Tilapia* is an easily cultivable species, and as a tropical species, easily survives in culture system. According to Edwards (2015); Abdel-Tawwab *et al.* (2014); Sayed *et al.* (2015); Mortuza and Al-Misned (2013), the Nile *Tilapia* cultured in ponds and cages has a unique quality of surviving at reduce dissolve oxygen, tolerance to large change in salinity, fast growth and management conditions.

As a result of these characteristics, the fish is greatly cultured all over the world (Ferdous *et al.*, 2013; Madalla, 2008; Mur, 2014). In the same vein, Mondal *et al.* (2010) made a comparison between cage and pond production of Perch (*Anabas testudineus*) and Tilapia (*Oreochromis niloticus*) under three management systems and opted for an integrated cage-pond system with high-value production, and the authors suggested that fish farming in cages and ponds in an integrated system will be the better option for rural aquaculture, considering the production and economic benefits. Comparatively, Ochang *et al.* (2014) showed great preference to catfish farming in cages, where artificial feeds were used to monitor growth of fish in different compartment. However, the culture and production of fish in cages has been a relatively recent aquaculture innovation (Tacon and Halwart, 2005). Alam *et al.* (2014) explained and demonstrated that cage/pond culture of fish is the raising of fish from fingerlings to harvestable size in containers (cages) enclosed on all sides and bottom by wooden stalls, hard wire cloth, net or other materials that allow free circulation of water in/and out of the cage. Fish cage culture allows intensive production of fish without conventional preparation for aquaculture. Alam *et al.* (2014) and Fečkaninová *et al.* (2017) explain that fish farming in cage and pond is a fast development in fish producing sector in the world and a major source of food security. Perhaps, the earliest type of aquaculture was the earthen pond system practised in the pre-historic time, Balarin and Haller (1982), who described the earthen pond as a synthetic dams, reservoir or lake constructed entirely from soil materials, manually or mechanically in a site with excessive water retention potentials. Thus, can simply be described as a water body that is enclosed by earth.

Considering the importance and prospects of aquaculture for accelerated production of fish using the cage, concrete pond and earthen pond systems especially in developing countries like Nigeria and recognising the potentials of fish farming in underutilized water bodies such as Otamiri River in South-East, Nigeria, the present research is undertaken to show a comparative study of growth performance and production potential of *Clarias gariepinus* fingerlings reared in cage, concrete pond and earthen pond systems respectively with specific objectives to show the effect of stocking density on growth performance and production potential of *Clarias gariepinus* under these culture conditions, and to develop method of catfish cage culture in Inland open water body like Otamiri River.

MATERIALS AND METHODS

The Study Area and Duration

The study was carried out at the University of Agriculture and Environmental Sciences axis of Otamiri River between 1st March and August 31st 2019, a period of 184 days. It was done using cage and pond culture systems.

Construction of Cage and Predator Barrier Net

The fish net cage measured 2.5m by 2.5m x 2m. The following materials were used to construct the fish net cage: ½ “ netting material (210D/9), Nylon twine (210 D/9), Nylon twine (210 D/8), Rope (10,mm PE), Rope (4mm PE), Weaver's stick,)

The predator barrier net measuring 2.5 x 2.5 x 2m was constructed with the view to preventing the entrance of predators into the cage. The net was constructed with the following materials; Galvanized angle rods, Copper ½ wire mesh, Copper binding wire, Black paint for coating the net against rusting while in water.

The predator barrier net houses the fish net cage. Thereafter the cage was transported in a carriage truck from the construction site to the research site (Otamiri river) after clearing the site. A cross bridge was also constructed after lowering the cage to float on the water.

Stocking, Feeding and Management

Three thousand two hundred (3,200) pieces of fingerlings of catfish-*Clarias gariepinus* were purchased from Barnabas Fish and hatchery Farm at Mbguruchi, Owerri. The cage was stocked with 1,500 pieces of fingerlings of *Clarias* species of 10gms average weight (at a stocking density of 1,500 fingerlings) for the period March to August, 2019. They were fed twice daily at 5% body weight, morning and evening. For comparison a concrete pond of 100m x 10m x 1.5m, was also stocked with 1,500 *Clarias* fingerlings of 10gms average weight and managed simultaneously with the cage culture system. The researchers were responsible for the feeding and regular maintenance of the fishes, cage and the pond, (Plate vi).

Records and Data Collation

The cage culture system is described as Treatment 1 (T_1) and the concrete pond system is described as Treatment II (T_{11}). The data collated include the following parameters:

- Initial number of fingerlings stocked, Average weight of fish at stocking, Total weight at stocking
- Number of fish at harvest, Percentage survival, Average weight of fish at harvest and Total weight of fish at harvest.

The details of data collated are for fish production, stocking and harvesting; Weight frequency of harvested fish, Average weight of harvested fish. Bar chart shows weight frequency of harvested fish in cage culture against pond culture.

RESULT AND DISCUSSION

The three experimental treatments T_1 , T_{II} and T_{III} for cage, concrete pond and earthen pond cultures with initial stocking densities of 1,500 pieces of fingerlings respectively. The survival samples at the end were 1,250, 1,450 and 1,440 respectively, a survival rate of 83.3%, 93% and 96% respectively. Total weight for each fish were 415.7gm, 350.8gm, 420gm Table I.

The number of fishes harvested for the three experimental trails are T_1 1250, T_{11} 1400, and T_{111} 1450 with corresponding average weight of 332.6gm, 250.6gm and 280.65gm. The result also reveal that total also revealed that weight total of the fish at harvest were T_1 415.7gm, T_{11} 350.8gm, T_{III} 420gm and percentage survival rates of T_1 83.3%, T_{11} 93.3% and T_{III} 96.6%. The transcend that the earthen pond system has the highest performance in comparism to cage and concrete system. T_{III} 96.6% had the highest production rate, with lower average weight, 250gm. Alam et. al (2014) explain that production rate is correlation of stocking density on growth performance, and production potential of tilapia (*Oreochromis niloticus*). The researchers observed a higher production for a 150 fish m^{-3} for a T_{150} cage, whereas a lower production rate was recorded for T_{150} in 200 fish m^{-3} . In the same vain, Osofero et. al. (2017) suggested that studies in production and biomass of fish in cages and ponds, stocking density is of great importance; for optimum productivity. Osofero et.al (2017) also showed that the highest production of tilapia (*Oreochromis niloticus*) at the stocking of density of 200 fish m^{-3} was most ideal. In contrast to this, Balcázar et.al. (2006) with hybrid red Tilapia stocked at density of 200, 300 and 400 fish m^{-3} in replicated cages, obtained the highest production at the density of 400 fish m^{-3} . However, Asase (2013) conducted a study in Ghana with the stocking density of 50, 100 and 150 fish m^{-3} and the highest gross production was obtained in 150 fish m^{-3} in cage culture system. Closely, Ofori et.al (2009) reported the highest stocking density of 7000 fish in 48 m^{-3} . This research resulted in less gross and net yields compared to other researches mentioned above in cage culture system. From all these accounts, it can be said that stocking density affects the growth performance and production potential of fish under culture condition. Apart from Asase (2013) who showed that stocking density of 150 fish m^{-3} guarantees the highest gross production in 150 fish m^{-3} in cage culture system, information is lacking on the effect on stocking density on mean final individual body

weight (gm), mean individual weight gain (gm), average daily gain (gm), percentage(%) weight gain, specific growth rate and production rate ($\text{g m}^{-3} \text{ day}^{-1}$).

In present research, the low percentage survival of T_1 (83%) is attributable to the high water depth where the cage was floated, thereby making it fairly difficult for the fingerlings to maximise feed in-take at the initial stage. T_{III} has highest performance due to nutrient rich environment, hence best alternative aquaculture system.

The survival rate of the fingerlings 1,250 and 1,450, was 83.3% and 96.66% for T_1 and T_{II} , compares with the range of survival rate obtained by Oroseet. *al* (2018), and also in line with Odin *et. al.* (2009), Odin and Boliver (2011), Amofo-Yeboah (2013). However, Haylor and Pascual (1991) reported a survival rate of 44% and 49% after 80 days of feeding *Oreochromis niloticus* fingerlings with testosterone (40mg/g) diet. Consequent upon these observations, a correlation between survival rate, weight gain and stocking density of fish fingerlings has been postulated by a number of authors. A production rate of 1,250 and 1,450 T_1 and T_{II} was observed in the present research. Alam *et. al* (2014) showed that the highest production rate was observed in T-150 for the stocking density of 150 fish m^{-3} . The lower production rate was recorded at a lower stocking density (100 fish m^{-3}) and higher stocking density (200 fish m^{-3}). Osofero *et. al.* (2007) found the highest production (28560g m^{-3}) of *Oreochromis niloticus* fingerlings at the stocking density of 400 fish m^{-3} . Asase (2013) conducted a study in Ghana with the stocking densities of 50, 100 and 150 fish m^{-3} and the highest gross production was obtained in 150 fish m^{-3} in cage culture system. Ofori *et. al.* (2009) reported the highest stocking density (7000 fish 48 m^{-3}) which resulted in less gross and net yields compared to others in cage culture condition. Mondal *et. al.* (2010) concluded that integrated cage-cum-pond system culture with high-valued fingerlings is a more suitable option than the conventional mixed culture system, due to high yield, maximum feed efficiency and more economic return. From the result of the researches under reference, stocking density and the culture medium, the cage and pond system play major roles in the production capacity of fingerlings in culture.

CONCLUSION AND RECOMMENDATION

Data collated from the research showed that the average weigh of the fish at harvest in the earthen pond system was 420g, better than the cage and concrete pond systems of 250.6gm and 350.8gm. Hence, the earthen pond system is a more viable aquaculture production system with very high return on investment and low cost of production. The potentials of Otarniri River is grossly unexploited. Therefore diversifying the resources of the river through cage and earthen pond fish farming will make for a gap-bridge for improved and accelerated fish production in the river.

It is recommended that earthen pond and cage system are promoted and practised in riverine communities in Nigeria especially where there is vast stretch of rivers like Otamini River. Government is encouraged to provide fishing materials especially cages and net to support the fishers. Financial assistance is required by government to the fishers to argument their needs especially in purchase of fishing materials.

Table 1: Comparative analysis of Treatments Data of Weight Frequency of Harvested Fish

S/N	Item	Treatment I, cage culture system	Treatment II, Concrete Pond culture system	Treatment III, Earthen Pond culture system
1.	Number stocked	1500	1500	1500
2.	Average initial weight at stocking	15g	15g	15g
3.	Number harvested	1250	1450	1440
4.	Percentage survival (%)	83.3%	96.67%	96%
5.	Average weight at Harvest (gm)	332.6	250.6	352g
6.	Total weight at harvest (gm)	415.7gm	350.8gm	420gm

Table 2: Weight Frequency of Harvested fish

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Treatment I: Cage Culture System			Treatment II: Concrete Pond Culture System		Treatment III: Earthen Pond Culture System	
	Number	%	Number	%	Number	%
201-250	180	14.4	600	42.8	600	41.6
251-300	150	12	500	34.48	500	34.7
301-350	150	12	100	6.90	100	6.9
351-400	200	16	100	6.90	100	6.9
401-451	270	21.6	50	3.45	70	4.9
451-500	200	16	100	6.90	70	4.9
	1,250		1,450		1,440	
Percentage survival			$\frac{1450}{1500} \times \frac{100}{1}$		$\frac{1440}{1500} \times \frac{100}{1}$	
	$= \frac{1250}{1500} \times \frac{100}{1} = 83.3\%$		$= 96.67\%$		$= 96\%$	

Table 3: Average Weight of Harvest Fish using $x = EFX/EF$ on Average Weight of Harvested Fish

X group (gms)	Midpoint x	F	Fx	Midpoint x	F	Fx	Midpoint x	F	Fx
201-250	225.5	180	40590	225.5	600	135300	225.5	600	135300
251-300	275.5	150	41325	275.5	500	137750	275.5	500	137750
301-350	325.5	150	48825	325.5	100	32550	325.5	100	32550
351-400	375.5	200	75100	375.5	100	32550	375.5	100	32550
401-451	425.5	270	114885	425.5	50	21275	425.5	70	29785
451-500	475.5	200	95100	475.5	100	23775	475.5	70	29785
		ΣF	ΣFx		Σf	Σfx		Σf	Σfx
		1,250	415825		1450	383200		1,440	397720
$\bar{X}$		Σfx	332.6	$\bar{X}$	Σfx	264.3	$\bar{X}$	Σfx	276.2
		Σf	(gm)		Σf			Σf	

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GROWTH PERFORMANCE AND NUTRIENT UTILIZATIONS OF *HETROBRANCHUS BIDORSALIS* FED FERMENTED WHEAT BRAN MEALS DIETS

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ABSTRACT

The availability of suitable and economical feeds is a major limiting factor to sustainable fish farming and it is a source of fear to many fish farmers in Nigeria. Addressing this problem will make fish farming more attractive and sustainable; information should be available especially on feed sources that are less competitive and of low cost value. Agro by-products such as Wheat bran is a source of dietary energy in fish feed. Hence it was study in this work. This agro by-product was fermented at varying fermentation periods one day, four days and seven days. The fermented by-product was subjected to proximate analysis after which four days fermentation was selected for feed formulation. Four formulated isoproteic (40% crude protein) diets at 25%, 50%, 75% and 100% inclusion levels to replace maize meal. The diets were fed to *Hetrobranchus bidorsalis* for twelve weeks (12) indoor. The result obtained from this study showed that fish fed 100% inclusion levels showed significance difference ($p < 0.05$) compared to fish fed other diets and control. Fish fed 100% inclusion level diet had the highest mean weight gain, average daily growth rate, specific growth rate and relative growth rate compared to fish fed control diet. The nutrients utilization showed significant difference ($p < 0.05$) in fish fed 100% inclusion levels compared to those fed control diet. The highest feed conversion ratio, protein intake, protein efficiency ratio, gross protein value, protein rating and protein growth rate were recorded in the fish fed 100% inclusion levels while the lowest were recorded in the fish fed control diet. Key: *Hetrobranchus bidorsalis*, Fermented Wheat Bran, Growth Performance and Nutrient Utilizations).

KEYWORDS: *Heterobranchus birdosalis*, Fermentaed wheat bran, growth performance, Nutrient Utilization.

INTRODUCTION

The development of fish farming is often faces high feed cost, approximately 70 to 89% of total production costs, causing declining profit (Suprayudi, 2010). The high cost of fish feed has been recognized as a major factor militating against rapid development of aquaculture in the developing countries due to most of the conventional feedstuffs being used in human foods and animal feeds hence leading to their exorbitant prices and scarcity (Suprayudi, 2010). However, problem of high cost of feeding in aquaculture is further exacerbated due to the scarce and expensive nature of some of the ingredients used in the formulation of fish feeds.

Hetrobranchus bidorsalis (Geoffroy Saint-Hilaire 1809) belongs to the genus hetrobranchus and family Clariidae. It is one of the most cultured and economically important freshwater fish species that contributes immensely to the annual freshwater fish production in Nigeria. The economic benefits of this

fish species are due to its hardiness, fast growth, large size attainable and ability to withstand changes in the environmental conditions (Awodiran *et al.*, 2019).

Among the alternative of the local feed ingredients that can be used to feed catfish are fermented wheat bran which is considered as a by-product. Wheat (*Triticum aestivum*) is the first important and strategic cereal crop for the majority of world's populations. It is the most important staple food of about two billion people (36% of the world population). Worldwide, wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally (Breiman and Graur, 1995). It exceeds in acreage and production every other grain crop (including rice, maize, etc.) and is therefore, the most important cereal grain crop of the world, which is cultivated over a wide range of climatic conditions.

MATERIALS AND METHODS

Experimental Location

The experiment was carried out at Biological Garden of the Department of Biological Science, Yobe State University Damaturu, Yobe State, Nigeria. The university is located at 5km Gujba road Damaturu, situated at 11.678°N 11.946°E. The experiment lasted for Twelve weeks (3 Month) indoor.

Collection and Processing of Experimental Diets

The Maize and Wheat bran were purchased from feedstuffs market in Damaturu, Yobe State and sterilized for the study. The experimental fish was procured from MBG Mega Fish Farm 6km Gujba road Damaturu, Damaturu Local Government Area of Yobe State, Nigeria.

Wheat bran was collected in three different bowls, ground into powder, then sieved and fermented using solid fermented procedure as described by Pederson *et al.*, (2000) and Sogbesan *et al.*, (2012). Each sample was solidly fermented (wet at 10% moisture and keep in container at ambient temperature) for 24 hours (1 day), 96 hours (4 days), and 168 hours (7 days). Afterward, the fermented samples were sun dried for 94 hours (4 days approximately) as described. The fermented samples were taken to the laboratory for proximate and the best was used to replace maize at 25%, 50%, 75% and 100%. The diets were formulated using Pearson square method at 40% crude protein. Therefore, five (5) diets including control were formulated for the feeding trial.

Experimental Design

A Completely Randomized Design (CRD) was used in this experiment in which four experimental diets each comprising of three different ingredients to replace maize. Five different treatments in triplicate making fifteen experimental units were used for the indoor experiment.

One hundred and fifty (150) *Hetrobranchus bidorsalis* fingerlings were procured MBG Mega Fish Farm Damaturu and acclimatized for seven (7) days and fed with a control diet. Subsequently, they were randomly assigned to four (4) treatments in triplicate each and control. Ten (10) fish fingerlings were assigned in each plastic bowl of 30 litres volume of water were fed 5% of their body weight.

Growth and Nutrient Utilizations

The following growth and nutrient utilizations parameters were calculated as follows:

Weight gain = $Wf - Wi$, Average Daily Growth (ADG) = $Wf - Wi/t$, Relative growth rate (RGR) = $Wf - Wi/Wi \times 100$, Specific growth rate (SGR) = $\log Wf - \log Wi/t \times 100$ and Survival (SR) $Nf/Ni \times 100$. Feed conversion ratio (FCR) $Weight\ gain\ g/Feed\ intake\ (g)$, Protein intake (PI) $Total\ feed\ intake \times \% \text{ crude protein in the diet}$, Protein efficiency ratio (PER) $Mean\ weight\ gain\ g/ Mean\ protein\ intake\ (g\ of\ protein\ in\ 100g\ of\ diet/fish)$, Protein rating (PR) $Daily\ protein\ intake \times PER$, Protein growth rate (PGR) $\frac{\log P2 - \log P1}{n} \times 100$ and Gross Protein Value (GPV) = $\frac{A}{Ao}$.

Statistical Analysis

All the data collected were subjected to analysis of variance (ANOVA) at 95% probability level where the significant differences were detected. Means values were separated using Least Significant Difference (LSD).

RESULTS AND DISCUSSION

The proximate analysis of the fermented Wheat bran milled meal diets revealed that, the moisture content was highest in the diet D₄ with 10.87 ± 1.34 and diet D₂ had the lowest with 9.83 ± 1.34 . Diet D₂ had the highest dry matter content of 90.17 ± 1.45 and the lowest was recorded in diet D₄ with 89.13 ± 1.43 . The highest percentage ash and crude protein were recorded in diet D₅ with $5.62 \pm 0.54\%$ and 47.87 ± 1.48 while the lowest were recorded in the diets D₄ and D₁ with 5.33 ± 1.86 and 42.44 ± 1.43 respectively. Diet D₁ had the highest fibre content of 6.64 ± 1.42 and the lowest was recorded in diet D₂ with 4.66 ± 0.63 while the highest crude lipid was recorded in the diet D₄ with 7.47 ± 0.23 and the lowest was recorded in diet D₂ with 5.91 ± 1.86 . The nitrogen free extract recorded was highest in the diet D₂ with 29.31 ± 1.18 and diet D₅ had the lowest 22.49 ± 1.17 . There is a significance differences between the diets fed ($P < 0.05$).

The total initial weight of the fish fed experimental diets was highest in diet D₂ with 62.87 ± 0.35 g and the lowest was recorded in diet D₁ with 60.81 ± 0.21 g, while the mean initial weight was highest in diet D₂ with 6.29 ± 0.65 g and the lowest was in diet D₁ with 6.08 ± 0.37 g. Fish fed diet D₅ had the highest total final weight with 443.84 ± 1.29 g while the lowest was recorded in the fish fed diet D₁ with 303.91 ± 2.24 g.

The mean final weight recorded was highest in the fish fed diet D₅ with 53.28 ± 0.54 g and the lowest was recorded in the fish fed diet D₁ with 35.05 ± 1.86 g. The total weight gain recorded was highest in the fish fed diet D₅ with 382.77 ± 1.92 g and the lowest was recorded in the fish fed diet D₁ with 243.10 ± 0.65 g. The mean weight gain recorded was highest in the fish fed diet D₅ with 47.17 ± 0.84 g and lowest was recorded in fish fed diet D₁ with 28.97 ± 0.54 g. The values for average daily growth (ADG), specific growth rate (SGR) and relative growth rate (RGR) was highest in fish fed diet D₅ with 0.56g, 1.11g and 771.52g and the lowest value recorded was recorded in diet D₁ with 0.35g, 0.91g and 476.48g respectively. The mean initial length recorded was highest in the fish fed diet D₃ with 4.5 ± 0.21 and the lowest was recorded in the fish fed diet D₂ and D₄ with 4.3 ± 0.24 and 4.3 ± 0.13 . The mean final length measured was highest in the fish fed diet D₅ with 17.3 ± 0.54 cm and the lowest was recorded in diet D₁ with 16.3 ± 1.03 cm. The condition factor (K) recorded was highest in the fish fed D₅ with 1.04 and the lowest was recorded in diet D₁ with 0.81. The percentage survival rate recorded in the fish exposed to the experimental diets was highest in diet D₁, D₂, D₃ and D₄ with 86.67% each and the lowest was recorded in the fish fed diet D₅ with 83.33%. There is significant difference ($P < 0.05$) between the fish fed experimental diets.

The total feed intake recorded was highest in the fish fed D₅ experimental diet with 809.70 ± 2.32 g and the lowest was recorded in the fish fed D₁ (Control) diet with 659.42 ± 2.54 g. The mean feed intake recorded was highest in fish fed D₅ with 92.00 ± 0.92 g and the lowest was recorded in the fish fed diet D₁ experimental diet with 71.41 ± 1.54 g. Fish fed diet D₅ experimental diet had the highest feed conversion ratio (FCR) of 0.51 and the lowest were found in the fish fed diet D₁ experimental diet with 0.41. The protein intake and protein efficiency ratio recorded was highest in the fish fed diet D₅ experimental diet with 43.24 and 1.09 while the lowest were found the fish fed diet D₁ experimental diet with 29.99 and 0.97 respectively. The gross protein value (GPV) and protein rating (PR) recorded were highest in the fish fed diet D₅ with 1.12 and 0.59 while the lowest were found the fish fed diet D₁ (Control) with 1.00 and 0.35 respectively. The protein growth rate recorded was highest in the fish fed diet D₅ with 0.66 and the lowest was recorded in the fish fed diet D₁ with 0.49. There is a significant difference ($P < 0.05$) between fish fed experimental diets fed.

The result obtained from the proximate analysis of the fermented Wheat bran revealed that, the highest percentage moisture content, crude lipid and crude protein values were found in (7 days) fermentation while the proximate analysis of the experimental diets indicated that one hundred (100%) percent in inclusion level of the fermented sorghum bran meal diet had the best percentage crude lipid and crude protein level and the lowest crude fibre compared to others. The variation observed from the values often exists during the process of chemical analysis of experimental ingredient and diet was due to the variation in the fermentation period and inclusion levels as reported by Falaye *et al.*, (2014).

This was a result of fermentation level which improve the protein composition, reduce anti-nutrients substances and crude fibre content of the fermented wheat bran meals and diets. This result is in line with findings by Omoike *et al.*, (2020) reported that fermentation increase crude protein and decrease fibre content of un-sieved yellow maize. The results agreed with the findings by (Yuheng *et al.*, 2021) reported that fermentation of wheat bran with a mixed fungal strains reduce crude fibre level of the ingredient and improves protein content, and Fayeofori and Bob (2017) reported that fermentation of wheat bran improves protein content and reduces crude content and anti-nutrients of the wheat bran.

Nitrogen free extract (NFE) values recorded from this study was lowest in diet containing highest inclusion level of fermented wheat bran meal. This result is comparable with the values reported by Isaac *et al.*, (2020) and Kati, *et al.*, (2014) reported that fermentation improve the protein content and decrease nitrogen free extract of wheat bean as a functional ingredient in baking. The NFE values of the treatment diets with growth promoters decreased with increasing inclusion levels compared with that of the control diet. This result is in agreement with the findings of Murthy *et al.*, (2016) who reported a reduction in the NFE values of fish diet with growth promoters.

The results on growth performances of *Hetrobranchus bidorsalis* on varying inclusion levels in this study revealed that fish fed 100% inclusion level diet had the best mean final weight, mean weight gain, average daily growth rate, specific growth rate and relative growth rate compared to other fish fed treatments diets and control as well. The result obtained from this study is in agreement with Ayan *et al.*, (2015) reported better growth performance in *Ladeo rohita* fed fermented animal by-product blend as fishmeal. The result also is in line with the findings by Fayeofori, (2017) reported increase in weight gain, specific growth rate, average daily growth and survival rate of *Clarias gariepinus* (Burchell, 1822) fed wheat bran meal. The result obtained from this study is in agreement with Afe *et al.*, (2019) reported increase in growth performance in *Hetrobranchus bidorsalis* fed *Eucalyptus globulus* leaf supplemented diets. The result obtained on condition factor (K) revealed that fish fed diet containing 75% and 100% inclusion level had the best condition factor compared to others. This result agreed with Effiong and peter (2019) reported good condition factor in hybrid catfish *Clarias gariepinus* x *Hetrobranchus bidorsalis* under various densities. This result is in line with Oyelere *et al.*, (2018) reported good condition factor in *Clarias gariepinus* fed varying levels of *Albizia lebbbeck* leaf meal. The result obtained on condition factor agreed with Micheal *et al.*, (2019) reported 1.55 to 3.63 condition factor in *Clarias gariepinus* fed fermented ground nut shell diets.

The results on nutrients utilization obtained from this study revealed that fish fed diet containing 100% inclusion level had best feed intake, feed conversion ratio, protein intake, protein efficiency ratio, gross protein value, protein rating and protein growth rate compared to others fed treatment diets and control. The results obtained from this study revealed that the experimental fish utilized the diet very well as observed in the results presented. The result obtained is in line with Wilfred *et al.*, (2012) reported in *Clarias gariepinus* fed variegated grasshopper. The results obtained also is in line with Eyidu and Etim (2018) reported better feed conversion ratio, protein efficiency ratio and protein conversion ratio in African catfish fed fermented Bambara nut meal as substitute of fishmeal. The results also agreed with Fakolade *et al.*, (2021) reported better feed utilization in African catfish *Clarias gariepinus* fingerlings fed *Laucera leucocephala*. The result also agreed with the findings by Omoike *et al.*, (2020) reported efficient nutrient utilizations in African catfish fed varying inclusion level of fermented un-sieved yellow maize. The result obtained also agreed with Bernadine, (2017) reported increase in growth performance and better feed conversion ratio in *Clarias gariepinus* fed fermented wheat (*Tritium spp*) waste meal.

CONCLUSION

This study revealed the positive effects of incorporating fermented Wheat bran meal into the diet of *Hetrobranchus bidorsalis*. Feeding *Hetrobranchus bidorsalis* with diets incorporated with four days (96 hours) fermented wheat bran meal at 100% inclusion levels resulted in an improvement on growth performance, survival rate and nutrients utilisations.

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Table 1: Ingredient Composition (g/100g) of the Experiment Diets

S/N	Ingredients (g/kg)	Inclusion Levels				
		0% Diet 1	25% Diet 2	50% Diet 3	75% Diet 4	100% Diet 5
1	Fish Meal	33.33	33.33	33.33	33.33	33.33
2	Soybean Meal	30.34	30.34	30.34	30.34	30.34
3	Maize Meal	31.33	23.50	15.67	7.83	0.00
4	FWBM	0.00	7.83	15.67	23.50	31.33
5	Vitamin premix	1.50	1.50	1.50	1.50	1.50
6	Starch	2.00	2.00	2.00	2.00	2.00
7	Salt	0.50	0.50	0.50	0.50	0.50
8	Oil	1.00	1.00	1.00	1.00	1.00
Total		100	100	100	100	100
Cal. % Crude Protein		40.00	40.00	40.00	40.00	40.00

Key: FWBM = Fermented Wheat Bran Meal

Vitamin and Minerals premix: Vitamin A -20,00,000 I.U.; D3- 4,00,000 I.U.; E - 200,000 I.U; K -1,200mg; B1- 10,000mg.; B2- 30,000mg.; B6- 19,000mg.; B12-1,000.; Niacin-200,000mg.; Folic Acid-5,000mg.; Panth Acid-50,000mg.; Biotin-400mg.; Antioxidant 125g.; Vitamin C-150g.; Choline chloride-400g.; Manganese-30g.; Zinc-40g.; Iron-40g.; Copper 4g.; Iodine-5g.; Selenium-0.2mg.; Cobalt-0.2mg.; Calcium-600g.; Lysine-100,000mg.; Phosphorus-4,000g.; Methionine-100g. (AGRO BAR-MAGEN NIG.LTD).

Table 2: Growth Performance and Nutrient Utilizations of *Hetrobranchus bidorsalis* Fed Fermented Wheat Bran Meal Diets for 84 Days

	Experimental Diets					SEM
	D ₁ Control	D ₂	D ₃	D ₄	D ₅	
Inclusion Levels %	0	25	50	75	100	
Total Initial Weight (g)	60.81±0.21 ^c	62.87±0.35 ^a	62.62±0.71 ^a	62.69±0.64 ^a	61.07±1.62 ^b	0.05
Mean Initial Weight (g/fish)	6.08±0.37 ^a	6.29±0.65 ^a	6.26±1.82 ^a	6.27±1.76 ^a	6.11±0.27 ^a	0.75
Total Final Weight (g)	303.91±2.24 ^e	335.33±2.35 ^d	352.42±1.34 ^c	394.83±1.57 ^b	443.84±1.29 ^a	0.43
Mean Final Weight (g/fish)	35.05±1.86 ^e	38.68±1.37 ^d	40.65±1.94 ^c	45.54±0.61 ^b	53.28±0.54 ^a	0.87
Total Weight Gain (g)	243.10±0.65 ^e	272.46±2.75 ^d	289.80±1.47 ^c	332.14±1.05 ^b	382.77±1.92 ^a	0.95
Mean Weight Gain (g/fish)	28.97±0.54 ^e	32.39±0.54 ^d	34.39±0.58 ^c	39.27±1.27 ^b	47.17±0.84 ^a	0.48
Average Daily Growth Rate (%/fish)	0.35 ^b	0.39 ^b	0.41 ^b	0.47 ^a	0.56 ^a	
Specific Growth Rate (%/day)	0.91 ^b	0.94 ^b	0.97 ^b	1.03 ^a	1.11 ^a	
Relative Growth Rate (%/fish)	476.48 ^e	514.94 ^d	549.36 ^c	626.32 ^b	771.52 ^a	
Mean Initial Length (cm/fish)	4.4±0.32 ^a	4.3±0.24 ^a	4.5±0.21 ^a	4.3±0.13 ^a	4.4±0.21 ^a	0.21
Mean Final Length (cm/fish)	16.3±1.03 ^c	16.6±0.28 ^b	16.5±0.13 ^b	16.9±0.11 ^b	17.3±0.54 ^a	0.04
Condition Factor (K)	0.81 ^c	0.85 ^c	0.90 ^b	0.94 ^b	1.04 ^a	
Percentage Survival Rate	86.67 ^a	86.67 ^a	86.67 ^a	86.67 ^a	83.33 ^b	
Total feed intake (g)	659.42±2.54 ^e	715.98±1.73 ^d	706.89±2.25 ^c	784.00±2.64 ^b	809.70±2.32 ^a	0.81
Mean feed intake (g)	71.41±1.54 ^e	77.51±0.72 ^c	76.31±1.58 ^c	84.60±1.74 ^b	92.00±0.92 ^a	0.54
Feed conversion ratio (FCR)	0.41 ^b	0.42 ^b	0.45 ^a	0.46 ^a	0.51 ^a	

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Protein intake (g/100g diet/fish)	29.99 ^d	34.10 ^c	34.34 ^c	38.92 ^b	43.24 ^a
Protein efficiency ratio (PER)	0.97 ^b	0.95 ^b	1.00 ^a	1.01 ^a	1.09 ^a
Gross protein value (GPV)	1.00 ^a	0.98 ^b	1.03 ^a	1.04 ^a	1.12 ^a
Protein rating (PR)	0.35 ^b	0.39 ^b	0.41 ^b	0.46 ^a	0.59 ^a
Protein growth rate (PGR)	0.49 ^b	0.60 ^a	0.61 ^a	0.65 ^a	0.66 ^a

Means in the Same Row with Different Superscripts are Significantly Different (P<0.05)

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ACCEPTABILITY AND GROWTH PERFORMANCE OF AFRICAN MUD CATFISH (*CLARIAS GARIEPINUS*) FED PROBIOTIC (*Saccharomyces cerevisiae*) FERMENTED SOYABEAN MEAL BASED DIETS

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ABSTRACT

The study investigated the effects of the probiotic (*Saccharomyces cerevisiae*) fermented soybean meal (SBM) diets on the acceptability and growth performance of the African catfish (*Clarias gariepinus*). A total of one hundred and twenty (120) African catfish (*Clarias gariepinus*) juveniles (weight: 31.64±0.55g and total length: 15.74±0.08cm) were obtained from Freedom Fisheries, Nsukka Enugu State. The Fish was transported to the wet laboratory of the department of Zoology and Environmental Biology, University of Nigeria, Nsukka in a 20litre container and acclimated for 2weeks before the commencement of the study. They were fed commercial diets twice a day with diets containing 45% crude protein before the commencement of the experiment. Treatment diets coded A-D, representing 0.20%, 0.35%, 0.45% and 0.00%(control) *Saccharomyces cerevisiae* dietary inclusion respectively were compounded. The mean time to strike the dietary pellets in the different treatments showed significant differences ($p < 0.05$). The highest(longest) time to strike occurred in treatment D(0.00% *S. cerevisiae* inclusion- Control)-3.39 ± 0.64 seconds. This was followed by treatment A(20% *S. cerevisiae* inclusion)-2.50 ± 0.34 seconds. There was no significant differences ($p < 0.05$) in the mean weights of the catfish fed *S. cerevisiae* based diets and the control. The mean weights of the catfish within each dietary treatment however significantly increased throughout the 8-week culture period. It was concluded that probiotic inclusion in fish diet enhances diet acceptability and growth performance of African Catfish(*Clarias gariepinus*) at levels of up to 0.45% .

Keywords: *Saccharomyces cerevisiae*, weight gain, diet, catfish, soybean

Introduction

Fish feed remains one of the greatest challenges to sustainable catfish aquaculture in Nigeria as it constitutes over 60% of the total variable cost of any meaningful fish farm venture (Oghale *et al.*, 2019). The most critical component of catfish feed that has continued to spike its cost is fish meal. Fishmeal is highly needed in aqua diets due to its high contents of essential nutrients, balanced amino acid profile, good growth performances and it's high acceptability by most aquatic animals (Younis and Mahboob, 2020). The high demand, high cost and the limited supply of fishmeal which are majorly satisfied by importation, have compelled trials on probable alternative protein sources for aquaculture diets. Soybean have been tried for a probable affordable replacement for fish meal in catfish feed but presents the problems of palatability and nutrient availability (Ukonze *et al.*, 2021). The probiotic (*Saccharomyces cerevisiae*) is found to be efficient in the production of extra-cellular enzymes (amylases, proteases and lipases) which greatly aid digestion and nutrient availability to the fed animal (Dawood *et al.*, 2020). It also contains amino acids, vitamins such as niacin, folic acid, riboflavin and biotin, as well as other minerals which are co-factors required for growth (Ezenwaji *et al.*, 2012). This research therefore sought to find the effect of *Saccharomyces cerevisiae* fermented soybean meal diet on the diet acceptability and growth performance of the catfish fed the diets.

MATERIALS AND METHODS

Experimental Site and Fish

This study was performed at the Wet Lab of the Department of Zoology and Environmental Biology, University of Nigeria, Nsukka, Enugu State.

A total of one hundred and twenty (120) African catfish (*Clarias gariepinus*) juveniles (weight: 31.64 ± 0.55 g and length: 15.74 ± 0.08 cm) were obtained from Freedom Fisheries, Nsukka Enugu State. The fish was transported to the laboratory in 20litre container and acclimated to laboratory conditions for 2weeks before the commencement of the study and were also fed commercial diets twice a day with diets containing 45% protein before the commencement of the experiment. During the course of the experiment, the physico-chemical parameters of the water were regularly checked and maintained within the acceptable limits for the fish species.

Experimental Diet

The diet was formulated from locally available feed materials namely: Fish meal, soya bean meal, corn meal, fish oil, lysine, methionine, vitamin and mineral premix. The feed formation was based on pearson square method (Eyo, 2004). The proximate composition of feed ingredients was analyzed to determine the carbohydrate, ash, moisture, fat, fibre and crude protein contents.

Commercial samples of *S. cerevisiae* (Royal Gold[®]) was bought from Ogige market and attenuated following standard methods. In formulating the feed, the live *S. cerevisiae* and the locally available feed materials were then weighed out with an electronic weighing balance in quantities needed to compound the feed. Feed formulation puts mixtures of feedstuffs and feed additives into a usable form. The experimental feed consists of four diets (Diets A-D) (Table 1).

Experimental Design and Procedure

The experiment adopted the Completely Randomized Design (CRD) involving 4 treatments (Treatments A-D) and three replicates. Treatment A, B, C contained 0.20%, 0.35g/kg and 0.45g/kg inclusions of the *S. cerevisiae* and treatment D (control) contained 0.00% inclusion of the *S. cerevisiae* respectively. The fish were stocked at a density of 10 fish per plastic bowl of 45 litres and covered with nets to prevent the fish from jumping out. The fish were fed the experimental diet for a period of 8 weeks at the rate of 5% body weight per day, at 8:00hours and 16:00hours. The water quality was maintained by changing the water in the plastic bowl at least twice in a week. The body weight and standard length were measured fortnightly using an electronic balance and metre rule respectively and the values used for adjusting the feeding levels.

Table 1: Composition of dietary ingredients in experimental diets(%)

Ingredients	A	B	C	D
Soybean meal(SBM)	37.22	42.38	47.54	32.06
Fish meal	21.38	16.07	10.81	26.74
Corn meal	34.20	34.20	34.20	34.20
Methionine	0.5	0.5	0.5	0.5
Lysine	0.5	0.5	0.5	0.5
Premix	1.7	1.7	1.7	1.7
Oil	3.3	3.3	3.3	3.3
Binder	1	1	1	1
Probiotic	0.20	0.35	0.45	0
Total	100	100	100	100

Data Analysis

Data obtained from the experiment were subjected to one-way analysis of variance (ANOVA). Least Significant Difference(LSD) was used to separate means at 5% confidence level($P < 0.05$).

RESULTS AND DISCUSSION

There were significant differences in the mean time to strike each of the dietary pellets (Table 2). It took the catfish 1.38 ± 0.05 seconds to strike the diet containing 0.45% *S. cerevisiae* supplemented diet (Treatment C), making it the lowest (shortest) time to strike and 3.39 ± 0.64 seconds to strike the diet containing 0.00% *S. cerevisiae* supplemented diet (Treatment D-control), making it the highest(longest) time to strike. Other treatments' time to strike values are shown in Table 2.

Table 2: Time to strike and acceptability of *S. cerevisiae* supplemented diet by *Clarias gariepinus* juveniles

Treatments	Time to strike (s)	Acceptability (s^{-1})
A (0.20%)	2.50 ± 0.34^b	0.40 ± 0.03^b
B (0.35%)	2.28 ± 0.16^c	0.44 ± 0.01^c
C (0.45%)	1.38 ± 0.05^d	0.73 ± 0.02^a
D Control	3.39 ± 0.64^a	0.30 ± 0.01^d

*Means with different alphabet superscript along each column were significantly different($p < 0.05$).

At the commencement of the study, the initial weight of juvenile *Clarias gariepinus* were similar between the groups. As expected, weight increased significantly as the experiment progressed from week-0 to week-8. The mean weight increased in all treatments such that there was no week when weight was not different within and between treatments (Table 3).

Weight gain was positive in all the groups from week 2 to week 8 except fish raised on diet A (0.20% probiotic based diet). While other groups including control gained weight approximately linearly from week 2 to week 8, fish fed 0.20% *S. cerevisiae* supplemented diets had a weekly sigmoid like growth curve (Figure 1). Weight gain was highest in fish fed 0.45% *S. cerevisiae* modified diet, followed by the 0.35% *S. cerevisiae* modified diet. The control treatment and 0.20% *S. cerevisiae* modified diet had similar magnitude of gain in weight. Weight increment depended on the fraction of probiotic supplementation ($F = 5.617$, $p = 0.001$, $\eta_p^2 = 0.057$) and the duration of administration ($F = 13.185$, $p < 0.0001$, $\eta_p^2 = 0.124$).

Table 3: Mean weight of *Clarias gariepinus* juvenile raised on *S. cerevisiae* based diet for 8-weeks

Treatments	Duration (week)				
	0	2	4	6	8
A(0.20%)	22.75 ± 9.36^{a1}	26.93 ± 10.24^{a1}	31.05 ± 13.00^{a2}	36.68 ± 15.71^{a2}	43.47 ± 19.24^{a3}
B(0.35%)	21.07 ± 7.17^{a1}	29.03 ± 9.96^{a1}	32.96 ± 11.52^{a2}	38.06 ± 13.39^{a2}	46.40 ± 17.56^{a3}
C(0.45%)	20.89 ± 8.51^{a1}	29.10 ± 11.63^{a1}	34.50 ± 12.12^{a2}	40.26 ± 12.96^{a2}	48.54 ± 14.50^{a3}
D(0.00%) - Control)	26.59 ± 8.62^{a1}	33.35 ± 11.97^{a1}	37.19 ± 13.01^{a2}	40.54 ± 13.96^{a2}	48.89 ± 16.70^{a3}

Means with different alphabet superscript along each column were significantly different ($p < 0.05$) while means with different numerical superscripts along each row were significantly different ($p < 0.05$).

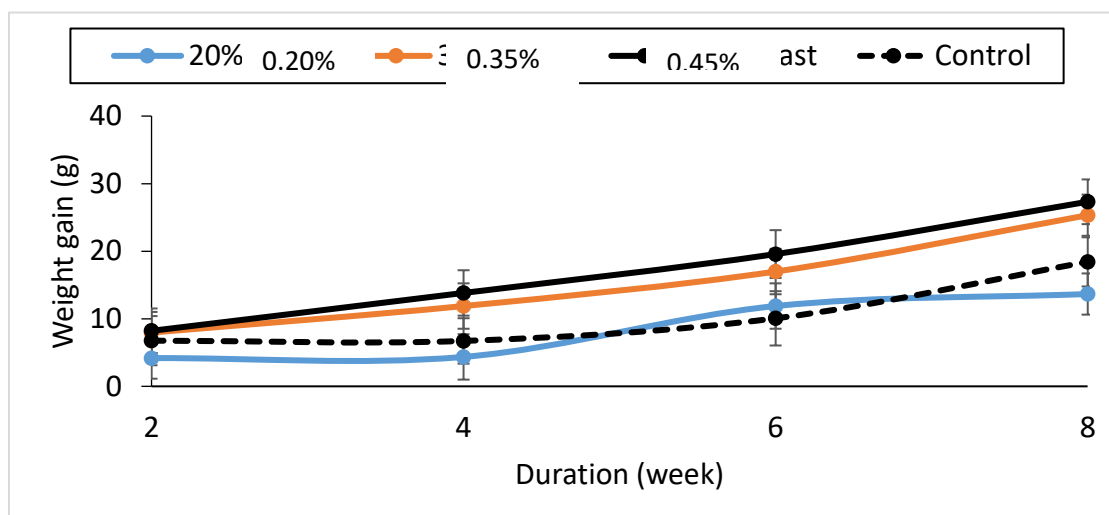


Figure 1: Weight gain in *Clarias gariepinus* juvenile raised on *S. cerevisiae* supplemented diet for 8-week

There were significant differences $p < 0.05$ in the specific growth rate (SGR) of catfish fed *S. cerevisiae* based diets. The specific growth rates of diets B(0.35%) and C(0.45%) were higher than that of the control and diet A (0.20%) Fig. 2. SGR was also influenced by the duration of the feeding.

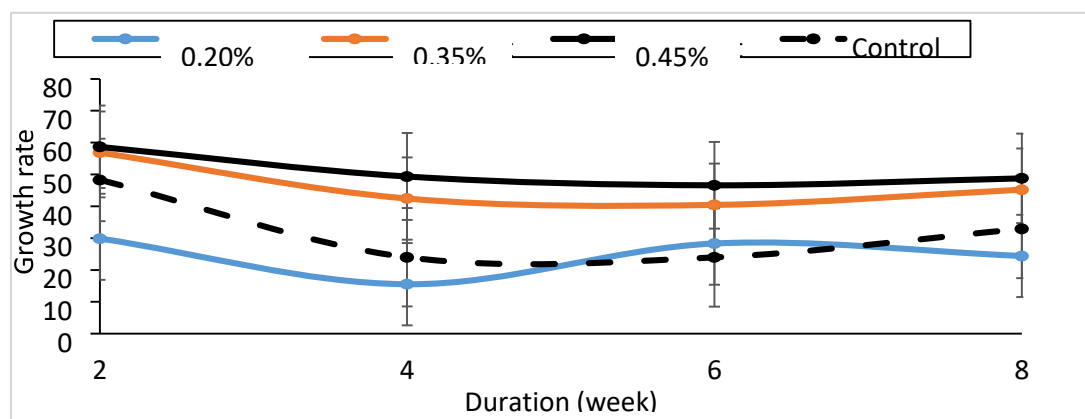


Figure 2: Specific growth rate of *Clarias gariepinus* juvenile raised on *S. cerevisiae* supplemented diet for 8-week

The interaction of the factors affecting internal motivation or drive for feeding on specific diets range from intrinsic factors related to extrinsic ecological factors involving the living conditions especially food and feeding habits of the fish (Eyo, 2004). Single cell proteins such as micro algae, bacteria and *S. cerevisiae* are alternative non-conventional protein sources and have been viewed as promising substitutes for fishmeal in fish diets (Zaid *et al.*, 2011).

From the result of this study, the time to strike of *S. cerevisiae* treatment diets were shorter than that of the control (Table 2). This agrees with the result of Dawood *et al.* (2020) on the increase of acceptability of Nile tilapia exposed to *S. cerevisiae* based diets and may be attributed to the significant improvement in the organoleptic properties of the *S. cerevisiae* based diets.

An increase in weight was noticed at the *S. cerevisiae* based diets throughout the period of the study. Treatment C (0.45%) inclusion of *S. cerevisiae* had the highest weight gain from week 2 to week 8 when compared to other treatments and the control. This agrees with the result of (Zaid *et al.*, 2011) on the

inclusion *S. cerevisiae* in the diet fed lake trout. The better weight gain and specific growth rate observed in the *S. cerevisiae* based diets (except in diet A - 0.20% *S. cerevisiae* inclusion) may be due to the enzyme rich qualities of *S. cerevisiae* which enables enhanced diet acceptability and effective feed utilization.

Conclusion

S. cerevisiae inclusion in fish diet enhances diet acceptability and growth performance of African Catfish *Clarias gariepinus*. From the results of this study, *S. cerevisiae* can be included in catfish diets by up to 0.45%.

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SERUM BIOCHEMICAL PARAMETERS OF *CLARIAS GARIEPINUS* (BURCHELL, 1822) FINGERLINGS FED DIETARY LEVELS OF FERMENTED *MORINGA OLEIFERA* (LAM.) KERNEL MEAL

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ABSTRACT

The effects of Fermented *Moringa oleifera* (Lam) kernel meal for 72 hours (FMOK_{72H}) as Soyabean Meal (SBM) replacement in the diets of *Clarias gariepinus* fingerlings on the serum biochemical parameters were investigated for a period of 15 weeks. FMOK_{72H} replaced SBM at 0 (control), 25, 50, 75 and 100% inclusion levels in five iso-nitrogenous (40% crude protein) diets. 150 *C. gariepinus* fingerlings were randomly distributed into 15 (100L) plastic tanks at 10 fish per tank in triplicate per treatment in Complete Randomize Design (CRD). 5% body weight of experimental diets were fed twice daily at 8.00am and 6.00pm. 2ml of blood from 3 randomly sampled fish per treatment were drawn from the caudal vein via 2ml syringes and dropped into EDTA bottles. The serum urea and ions of 25-to-100% FMOK_{72H} fed fish against the control significantly differed ($P < 0.05$). Total serum glucose of 25-to-50% FMOK_{72H} fed fish compared to control were not significantly different ($P > 0.05$) while the serum total protein of 100% FMOK_{72H} fed fish against the control significantly differed ($P < 0.05$). There were significant reduction ($P < 0.05$) of total serum cholesterol of 25-to-100% FMOK_{72H} fed fish against the control. *C. gariepinus* survival ranged from 77-to-100% across the treatments. Thus, FMOK_{72H} replacing SBM in the experimental diets of *C. gariepinus* fingerlings enhances its serum total protein with significant survival.

Keywords: *Clarias gariepinus*, Fermented *Moringa oleifera* Kernel, Serum, Soyabean, Experimental diets.

1.0 Introduction

Fish is a vital source of high-quality protein, providing approximately 16% of the animal protein consumed by the world's population. It is an important protein source in regions where livestock is relatively scarce (Dienye and Olumuji, 2014). It supplies less than 10% of animal protein consumed in North America and Europe but 17% in Africa, 26% in Asia and 22% in China (FAO, 2006). Its culture is one of the fastest growing sectors of the world's animal production with an annual increase of about 10% (Dienye and Olumuji, 2014). The inclusion of plant protein sources in the ration of fish requires investigation on the limiting factors in the plant ingredients such as high crude fibre content and anti-nutrients (Dienye and Olumuji, 2014). Excessive inclusion of the plant ingredients in feed may result in slower growth rates and general poor performance of cultured fish species (Nwanna *et al.*, 2009). *Moringa oleifera* a member of the *Moringaceae* family is a fast growing plant widely available in the tropics and subtropics with several economic importance. It is widespread, drought tolerant with negligible amount of tannins, trypsin and amylase-inhibitor (Giami, 2002). Earlier studies have shown that *M. oleifera* (leaves and seeds) is a promising protein source for use in diet of Tilapia (Richter *et al.*, 2003). *Clarias gariepinus* is the most sought after species among fish farmers and consumers because it commands good commercial values in not only Nigeria but all over Africa (Dienye and Olumuji, 2014). It can tolerate a large variety of feedstuffs and is very resistant to changing and suboptimal water conditions. It can be farmed in high densities reaching production levels of 6 to 16 metric tonne / ha on an annual basis when raised in monocultures and fed high quality fish feed (Fagbenro, 1992).

This study aimed to investigate the impacts of replacing SBM with FMOK_{72H} in the diets of *C. gariepinus* fingerlings on serum biochemical parameters and survival.

Materials and Methods

Experimental Procedure

The experiment had fifteen treatment tanks (100 L plastic) with five test diets in triplicate per treatment. Thus: **D1:** 0% FMOK_{72H} against 100%SBM (Control), **D2:** 25% FMOK_{72H} against 75%SBM, **D3:** 50% FMOK_{72H} against 50%SBM, **D4:** 75% FMOK_{72H} against 25%SBM and **D5:** 100% FMOK_{72H} against 0%SBM. Each treatment was stocked with 10 *C. gariepinus* fingerlings.

Water Quality Parameters of the Experimental Tanks

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The water quality parameters monitored during the experiment were Dissolved Oxygen (DO), Hydrogen ions concentration (pH) and temperature ($^{\circ}\text{C}$). Using DO meter (AD630 DO Meter), Digital pH Meter and Mercury in Glass Thermometer.

Blood Sample Collection

The blood was collected from three randomly sample fish per treatment for serum biochemical analysis. 2ml of blood sample were drawn from each at the ventral part of the fish between the reproductive organ and the caudal fin via 2ml hypodermic syringes and dropped into EDTA bottles. The blood samples were immediately taken to Pathology laboratory, Department of Veterinary medicine, Ahmadu Bello University, Zaria for serum biochemical analysis.

Evaluation of the serum profiles of the experimental fish involved the determination of the urea, sodium, potassium, chloride, carbonate ions, total glucose, Bilirubin, total protein, albumin, globulin and total cholesterol. The blood sample was diluted with appropriate diluting fluids (Shah and Altindag, 2005). The urea, ions and total glucose were determined according to Hrubec and Smith (2000). Total Bilirubin, total protein, albumin, globulin and total cholesterol were determined by colorimetric methods of Galagaza *et al.* (2017).

Data Analysis

All data obtained were subjected to a one way analysis of variance (ANOVA) using SPSS 16 version and Duncan Multiple Range Test (DMRT) was used to determine the differences between the means and comparisons were made at $P < 0.05$.

Results and Discussion

Table 1.0 presents the experimental diets and proximate composition. Table 2.0 presents the water quality parameters of the experimental tanks. It is suitable for the culture of *Clarias gariepinus* (FAO, 2006). Table 3.0 presents the serum biochemical parameters of *C. gariepinus* fingerlings fed experimental diets. There were significant difference ($P < 0.05$) of urea and ions composition as the inclusion levels of FMOK_{72H} increased in the experimental diets. The highest urea ($6.8 \pm 0.1 \text{ mmol/dL}$) was from the control while the least ($4.9 \pm 0.0 \text{ mmol/dL}$) was from 100% FMOK_{72H} fed fish. There were no significance difference ($P > 0.05$) of serum total glucose of 50% FMOK_{72H} fed fish ($31 \pm 0.1 \text{ mmol/dL}$) against the control ($33 \pm 0.2 \text{ mmol/dL}$). The total serum protein were significantly different ($P < 0.05$) in the 100% FMOK_{72H} fed fish ($60 \pm 0.2 \text{ mmol/dL}$) compared to control ($49 \pm 0.1 \text{ mmol/dL}$). Thus, 100% FMOK_{72H} fed fish serum cholesterol ($2.2 \pm 0.0 \text{ mmol/dL}$) were significantly ($P < 0.05$) lower compared to control ($3.7 \pm 0.2 \text{ mmol/dL}$).

Table 1.0: Experimental Diets and Proximate Composition

Ingredient (%)	Diet 1 (Control)	Diet 2	Diet 3	Diet 4	Diet 4
Fish Meal	38.80	38.80	38.80	38.80	38.80
SBM	25.90	19.40	12.90	6.46	0.00
FMOK _{72H} ,	0.00	4.83	9.66	14.49	19.32
Yellow Maize	11.06	11.98	12.82	12.82	13.98
Wheat Offal	11.06	11.98	12.82	12.82	13.98
Cassava Flour	2.00	2.00	2.00	2.00	2.00
Methionine	1.50	1.50	1.50	1.50	1.50
Lysine	1.50	1.50	1.50	1.50	1.50
Palm Oil	1.50	1.50	1.50	1.50	1.50
Premix	2.50	2.50	2.50	2.50	2.50
Salt	1.00	1.00	1.00	1.00	1.00
Bone Meal	2.00	2.00	2.00	2.00	2.00
Chromic Oxide	1.00	1.00	1.00	1.00	1.00

Proximate (%)					
Dry Matter	8.20	11.69	8.23	7.65	5.62
Crude Protein	38.70	40.70	44.60	45.10	46.10
Crude Lipid	31.20	21.40	22.00	20.30	21.20
Ash	6.19	7.14	7.37	9.29	9.71
NFE	15.80	18.70	17.40	17.90	17.60

Table 2.0: Water Physico-chemical Parameters of the Experimental Tanks

Parameter	D1	D2	D3	D4	D5	FAO Values
Temp (°C)	25.11±01	25.31±02	24.21±01	26.02±02	25.03±00	29.0
pH	7.11±01	7.03±00	7.06±01	7.05±01	7.03±00	7.34
DO (mg/L)	5.12±00	5.65±01	5.81±02	5.64±01	5.70±02	6.23

Table 3.0: Serum Biochemical Parameters of *C. gariepinus* Fingerlings Fed Test Diets

Parameter (mmol/dL)	D1	D2	D3	D4	D5
Urea	6.8±01 ^a	5.8±01 ^b	5.1±00 ^c	5.1±00 ^c	4.9±00 ^c
Na ⁺	127±03 ^a	117±02 ^b	112±02 ^c	109±01 ^d	91±00 ^e
K ⁺	3.4±01 ^a	3.2±01 ^a	2.7±01 ^b	2.3±00 ^c	2.2±00 ^c
Cl ⁻	93±03 ^a	85±02 ^b	82±01 ^c	80±02 ^c	66±01 ^d
CO ₃ ⁻	31±01 ^a	30±01 ^a	29±01 ^a	28±01 ^a	27±01 ^a
Total Glucose	5.3±00 ^c	5.3±01 ^c	5.4±00 ^c	5.6±01 ^b	6.6±01 ^a
Total Bilirubin	33±02 ^a	32±01 ^a	31±01 ^a	28±02 ^b	22±00 ^c
Total Protein	49±01 ^c	51±01 ^c	54±01 ^b	55±02 ^a	60±02 ^a
Albumin	37±02 ^a	34±01 ^b	35±02 ^a	33±01 ^b	31±01 ^c
Globulin	29±02 ^a	22±01 ^b	24±01 ^b	17±01 ^c	15±01 ^c
Total	3.7±02 ^a	3.0±01 ^b	2.9±01 ^b	2.5±01 ^b	2.2±00 ^c
Cholesterol					
Survival	80±00 ^b	100±01 ^a	87±00 ^b	77±00 ^b	97±01 ^a

Mean with different superscript along the same row were significant different (P<0.05)

The serum biochemical parameters of *C. gariepinus* fingerlings fed fermented *M. oleifera* kernel diets revealed that the urea, sodium, potassium and chloride ions significantly (P<0.05) reduced as the inclusion level of FMOK_{72H} increased in the experimental diets. This agreed with Adeyemi and Elebiyo (2014) report that *M. oleifera* in diet can increase protein and decrease level of urea and creatinine in blood, thereby preventing renal dysfunction. It also contradicts the finding of Folorunso (2010) who reported a significant (P<0.05) increase in the serum parameters of *C. gariepinus* fed probiotics. Thus, incorporation of *M. oleifera* kernel meal in fish diets can be important in tackling nutrient deficiencies and enhance growth (Devarai *et al.*, 2016).

There were significant reduction (P<0.05) of the experimental fish serum total glucose as the inclusion of FMOK_{72H} increased in the experimental diets. The 100% FMOK_{72H} fed fish serum total glucose were significantly lower (P<0.05) than the control. This contradicts Suleiman *et al.* (2017) report that serum glucose levels are elevated during stress in fish primarily as a consequence of elevated blood catecholamine level. The fed fish were not stressful, since they accepted the experimental diets up to 100% FMOK_{72H}

against SBM. Thus, *M. oleifera* seed is a significant source of fat, protein, beta-carotene, vitamin C, iron, potassium and other nutrients with low toxicity (Barakat and Ghazal, 2016). There were no significant difference ($P>0.05$) of 50% FMOK_{72H} fed fish serum total Bilirubin compared with the control. But as the FMOK_{72H} inclusion in the experimental diets increased there were significant reduction ($P<0.05$) of serum total Bilirubin. This contradicts Adamu and Audu (2008) report that higher Bilirubin concentration in blood serum may be correlated to the destruction of red blood cells. *M. oleifera* seed possesses immune-boosting, anti-oxidant, anti-viral, anti-microbial, anti-inflammatory and anti-tumour suppression agents (Saini *et al.* 2014).

There were significant difference ($P<0.05$) of serum total protein of the experimental fish as the inclusion level FMOK_{72H} increased from 25-to-100%. This agreed with Ayoola (2011) report of increased serum total protein and triglyceride concentration in *C. gariepinus* fed 50% feed supplementation with poultry waste. This is so because the protein quality of the raw *M. oleifera* seed was enhanced by fermentation process. Fermentation increase crude protein contents, mineral composition and nutrients digestibility, reduces anti-nutrients, degrade crude fibres and eliminate indigestible carbohydrates of various feed resources (Skrede *et al.*, 2002. Jakobsen *et al.*, 2015. Dawood and Koshio, 2019). Analysis of the proximate composition of *M. oleifera* seeds has revealed high levels of protein with the dry seeds usually containing 332-to-383g / kg of protein (Abdulkarim *et al.*, 2005). There were significant reduction ($P<0.05$) of the fed fish serum albumin and globulin as the inclusion level of FMOK_{72H} increased in the experimental diets. This contradicts Adamu and Kori-Siakpere (2011) finding of increased value of serum globulin due to the effect of higher plant protein as an inhibitory agent on hydrolytic activity of protease in the liver of *C. gariepinus*. There were significant reduction ($P<0.05$) of serum total cholesterol of the fed fish as the inclusion level of FMOK_{72H} increased in the experimental diets. The 100% FMOK_{72H} fed fish total serum cholesterol were significantly lower ($P<0.05$) than the control. This agreed with Barakat and Ghazal (2016) report that *M. oleifera* seed is rich in Linoleic acid and Oleic acid that control cholesterol level in fish. It also agreed with Bamidele *et al.* (2015) findings of significant reduction ($P<0.05$) in serum and tissues cholesterol of *C. gariepinus* fed diets with increased inclusion levels of fermented *M. oleifera* seed meal against Soybean meal. There were significant ($P<0.05$) survival (77-to-100%) of the experimental fish across the treatments. This agreed with Bamidele *et al.* (2015) report of 70-to-100% survival of *C. gariepinus* fingerlings fed diets with fermented *M. oleifera* seed meal against Soybean meal.

Conclusion

Culturing *Clarias gariepinus* fingerlings with fermented *Moringa oleifera* kernel meal as Soybean replacement significantly enhances its serum total protein at 25-to-100% FMOK_{72H} inclusion levels, lowered serum total cholesterol at 100% FMOK_{72H} inclusion level (2.2 ± 00^e mmol/dL) against the control (3.7 ± 02^a mmol/dL) and 77-to-100% survival across the treatments.

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NUTRIENTS EVALUATION OF LEAF AND PEEL OF CASSAVA (*Manihot esculenta*) USING DIFFERENT PROCESSING TECHNIQUES

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ABSTRACT

Feed cost in aquaculture enterprise poses great challenge in producing fish at appreciable profit; while trying to address this hitch, there is need to supplement fish feed with other available and economical ingredients. This study investigated the proximate and mineral compositions of cassava leaf and peel using different processing techniques that could be economically of use in fish feed formulation. The experiment was conducted at Usmanu Danfodiyo University Sokoto. The fresh samples of leaves and peels of cassava (*Manihot esculenta*) were obtained and grouped into fresh, oven dried and sundried as the three processing techniques. Each group was replicated three times. The nutritive values obtained were subjected to ANOVA and the results elucidated both significant and insignificant differences among the differently processed cassava leaves and peels ($P < 0.05$). It could be concluded that cassava leaves and peels subjected to different processing techniques contained appreciable quantity of nutrients required by fish for growth and for other metabolic activities that can be augmented with some conventional ingredients. Further study on feeding trials at different inclusion levels using these processed unconventional feed ingredients is recommended.

Key Words: Cassava, Nutrients, Peels, Leaves, Minerals, Proximate composition analysis.

INTRODUCTION

Aquaculture enterprise is becoming a more common practice locally and internationally in large and small scales. Feed is a significant factor in enhancing the productivity and profitability of aquaculture (Akinrotimi *et al.*, 2007). Feed costs usually accounts for 60% of the total cost of production (Gabriel *et al.*, 2007). The future development of small-scale aquaculture system depends on the use of available local ingredients which will reduce feed cost (Edwards and Allan, 2004). According to Ayodeji, (2005) Cassava (*Manihot esculenta*) is one of the most important staple food crops grown in tropical Africa, whereas Nigeria produces about 25% of sub-Saharan Africa's output. Unlike the roots which heavily consists of carbohydrates, cassava leaves, a by-product of cassava root harvest, were (depending on the variety) rich in protein [14–40% of dried matter (DM)], minerals, vitamins B1, B2 and C, and carotenes (Adewusi and Bradbury, 1993). However, while the macro- and micro-nutrient contents of the leaves may be high, the processing techniques used can lead to huge losses of nutrients (Hahn, 1988). This research was aimed at investigating the nutrient contents of cassava peal and leaf processed with different techniques.

MATERIALS AND METHODS

Sample Preparation

The experiment was conducted at Agricultural Chemical Laboratory of Faculty of Agriculture and Biochemistry laboratory of Faculty of Science, Usmanu Danfodiyo University Sokoto. The sample of the cassava leaves and peels were collected from the University's farm. The samples of fresh leaves and peels of cassava were collected and divided into three groups as fresh, and to be processed by oven drying and sun drying.

Drying, Proximate and Minerals Analyses

Four (4) g of each sample (leaves and peels of the cassava) were oven dried at 65°C to constant temperature to determine the dried matter content. Four (4) g of the each sample were sun dried by exposing to the direct sunlight spread on a tray for 5 days. The dried matters were ground with pestle and mortar for subsequent chemical analyses. Moisture content, Crude Protein, Ash, Crude fiber, Crude Fat, Nitrogen-free extractive (N.F.E), Magnesium (Mg^{2+}) were determined according to AOAC (1995). Potassium (K^+) and Sodium (Na^+) were determined using flame photometer while Calcium (Ca^{2+}) and Phosphorus (P) were determined using Spectrophotometer. The samples from each group of processing technique after grounded were analyzed in three replicates.

RESULTS AND DISCUSSION

Proximate and Minerals composition of cassava leaves

Table1: Proximate composition of cassava leaves on different processing techniques

Processing techniques	Moisture %	Lipid %	Crude protein %	Ash %	Crude fiber %	*NFE
FCL	65.83±1.68 ^a	1.83±0.17 ^b	6.04±0.05 ^a	5.83±0.17 ^a	5.33±0.68 ^a	14.96±0.27 ^b
OCL	6.00±0.58 ^c	5.50±0.76 ^a	4.61±0.71 ^b	4.17±0.44 ^a	5.17±0.33 ^a	74.55±0.90 ^a
SCL	10.33±0.44 ^b	3.17±0.29 ^b	2.50±0.10 ^c	7.00±1.76 ^a	5.33±0.17 ^a	71.67±2.09 ^a

*NFE = Nitrogen Free Extract, FCL= Fresh Cassava Leaves, OCL= Oven dried Cassava Leaves, SCL= Sundried cassava leaves. Values with different superscripts along the columns were significantly different ($P < 0.05$)

The results of proximate compositions of cassava leaf presented in Table 1 revealed that Nitrogen Free Extract (NFE) was low in FCL which was similar to Lovell (1988) that recorded 14.30% but above the value

of Bradbury and Holloway (1988) recorded 7% and significantly ($P < 0.05$) differed from OCL and SCL. Highest crude protein obtained in FCL (6.04%) corroborated the 7% reported by Lovell (1988) but lower to those reported by Abu *et al* (2015) 25.37%; Gomez *et al.* (1985) 20- 23%; Nwokolo (1987) 38.1-19.7%; Rogers and Milner (1963) 17.8 - 34.8%. But the crude protein is higher than 1% in Bradbury and Holloway (1988) report.

Table2: Minerals composition of cassava leaves by processing techniques

Processing techniques	Sodium (Na) mg/kg	Potassium (K) mg/kg	Calcium (Ca) mg/kg	Magnesium (Mg) mg/kg	Phosphorus (P) mg/kg
FCL	45.00±1.44 ^c	2933.33±66.67 ^a	0.18±0.02 ^c	0.77±0.02 ^c	3.56±0.01 ^b
OCL	133.33±2.21 ^a	2033.33±16.67 ^b	0.47±0.06 ^b	2.20±0.05 ^b	2.50±0.01 ^c
SCL	61.25±1.44 ^b	1800.00±50.00 ^c	0.78±0.03 ^a	2.55±0.03 ^a	5.06±0.02 ^a

FCL= Fresh Cassava Leaves, OCL= Oven dried Cassava Leaves, SCL= Sundried cassava leaves. Values with different superscripts along the columns were significantly different ($P < 0.05$).

The results of mineral compositions of cassava leaves subjected to different processing techniques in Table 2 elucidated that there was highest sodium content of 133.33±2.21mg/kg in OCL which is close to the finding of Woot-tsuen *et al.*, (1968) who record 177.0mg/kg. FCL had the highest potassium of 2933.33mg/kg content with Calcium, Magnesium and Phosphorus being highest in SCL as 0.78mg/kg, 2.55mg/kg and 5.06mg/kg respectively.

Proximate and Minerals Compositions of Cassava Peels

Table 3: Proximate composition of cassava peels on different processing techniques

Processing techniques	Moisture %	Lipid %	Crude protein %	Ash %	Crude fiber %	*NFE
FCP	78.33±1.68 ^a	2.83±0.33 ^c	3.83±0.70 ^a	3.83±0.33 ^b	4.17±0.17 ^b	6.84±2.31 ^b
OCP	6.33±0.60 ^b	4.67±0.33 ^b	3.38±0.44 ^a	6.67±1.01 ^{ab}	6.83±2.68 ^a	72.11±3.83 ^a
SCP	5.00±0.50 ^b	8.67±0.44 ^a	2.86±0.39 ^a	8.00±1.53 ^a	8.00±2.31 ^a	67.47±2.80 ^a

*Nitrogen Free Extract, FCP= Fresh cassava peels, OCP= Oven dried cassava peels, SCP= Sundried cassava peels. Values with different superscripts along the columns were significantly different ($P < 0.05$).

The proximate compositions of cassava peel using difference processing techniques (Table 3) elucidated the lowest value of Nitrogen Free Extract (NFE) in FCP which differed significantly ($P < 0.05$) from other treatments and is lower from what Nwoko *et al* (2016), Abu *et al.*, (2015) and Otache *et al.*, (2017) reported as 87.53%, 74.83% and 75.20% respectively, conversely the values were similar to those of OCP and SCP. Crude protein content did not differed significantly ($P > 0.05$) among the treatments but were lower compared to Nwoko *et al.*, (2016) that reported 6.86%; conversely, the values were higher compared to 2.53% and 2.84% reported by Abu *et al.*, (2015) and Otache *et al.*, (2017) respectively. The lowest ash content of cassava peels among the treatments were higher than ash reported by Nwoko *et al.* (2016), Abu *et al.*, (2015) and Otache *et al.*, (2017) as 3.13%, 3.17% and 3.04% respectively, this may be partly due to the effect of processing techniques and partly due to factors like varietal, environmental and/or cultural practice difference of the cassava used as samples in the studies.

Table 4: Minerals composition of cassava peels on different processing techniques

Processing techniques	Sodium (Na) mg/kg	Potassium (K) mg/kg	Calcium (Ca) mg/kg	Magnesium (Mg) mg/kg	Phosphorus (P) mg/kg
FCP	66.67±2.21 ^b	7266.67±33.33 ^a	1.03±0.02 ^a	1.35±0.03 ^b	3.33±0.02 ^a
OCP	131.33±11.19 ^a	3683.33±44.10 ^b	0.37±0.07 ^c	2.13±0.02 ^a	2.02±0.01 ^b
SCP	125.42±4.39 ^a	1516.67±16.67 ^c	0.57±0.03 ^b	0.85±0.03 ^c	2.02±0.00 ^b

FCP= Fresh cassava peels, OCP= Oven dried cassava peels, SCP= Sundried cassava peels. Values with different superscripts along the columns were significantly different (P < 0.05).

The results of the mineral compositions of cassava peels stated in Table 4 elucidates highest amount of sodium in OCP which corroborates the work of Otache *et al.*, (2017) that reported a range of 70.4 - 173.8mg/kg and it does not differed significantly (P > 0.05) with SCP rather, was significantly (P < 0.05) differed with FCP. The calcium contents of the cassava peels which differed significantly among the treatments was highest in FCP that was lower to 11.20 - 19.88mg /kg as reported by Idugboe *et al.*, (2015). This may be as a result of geographical variation of the cassava varieties from which the samples of cassava in the studies were pulled.

CONCLUSION

The results of this study prove that cassava leaves and peels subjected to different processing techniques contained appreciable quantity of nutrients required by fish for growth and for other metabolic activities that can be augmented with some conventional ingredients.

RECOMMENDATION

Further study on feeding trials for fish at different inclusion levels using these processed unconventional feed ingredients is recommended.

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EFFECTS OF BLACK CUMIN-ADDITIVE DIETS ON GROWTH AND NUTRIENT UTILIZATION OF *Clarias Gariepinus*

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Abstract

Indoor experiment were conducted for 12 weeks to examine the performances of *Clarias gariepinus* fed inclusion levels (25%, 50%, 75%, and 100%) of black cumin (*Nigella sativa*) as immuno-enhancers, growth promoter and nutrient utilization. The aim of experiment was to determine the black cumin as phyto-biotic feed additives compared to control diets. For this experiment, five treatments (BcD1, BcD2, BcD3, BcD4, and BcD5) containing black cumin at the inclusion levels of 0, 25, 50, 75, and 100% each of the total diets and a control diet were used. A total of 600 catfish (15 ± 0.2 g) were used for experiment with 3 replications per treatment. Feed consumption, and weight gain were measured. The results of experiment indicated that diet 5 had the best results ($p \leq 0.05$) than the control diet. However, there were significant differences ($p \leq 0.05$) in mean weight gain (MWG) and specific growth rate (SGR) among treatments. Black-cumin-additives can substitute and included in commercial fish feed production and impart positive effects on growth and health performances of fish.

Keywords: Black cumin; Growth performance; Nutrient Utilization, Additives

Introduction

Black cumin (*Nigella sativa*) belongs to the family Ranunculaceae. Black cumin is an annual herbaceous plant growing in countries bordering the Mediterranean Sea and Asia, mostly as garden flower (Cheikh-Rouhou et al., 2008). Black cumin seeds contain various composition including proteins, carbohydrates, oil, vitamins and minerals. According to Abaza (2001), the percentages of crude protein (CP), ether extract (EE), crude fiber (CF), ash and nitrogen free extract (NFE) were 24.46, 28.38, 11.44, 5.69 and 23.49%, respectively. Atta (2003) conducted scientific investigations on nutritional value of black cumin seeds (*Nigella sativa* L.). They have depicted its composition moisture, oil, proteins, ash and total carbohydrates contents in the range of 3.8-7.0 percent, 22.0 to 40.35 percent, 20.85-31.2 percent, 3.7-4.7 percent and 24.9-40.0 percent respectively. Analysis of the proximate composition revealed that the spices had considerable carbohydrate and crude protein content, but low ash, fibre, moisture and fat except pepper which has high crude fat content. The objectives of this study was to evaluate the effects of black cumin-additive diets on the growth and nutrient utilization of *Clarias gariepinus*.

Materials and Methods

Experimental System and Fish

A total of six hundred and fifty (650) catfish (*Clarias gariepinus*) of average wet weight 15.0 ± 0.2 g and kept in aerated semi flow-through freshwater. A completely randomized design was used, where six hundred fingerlings of *Clarias gariepinus* were randomly allocated to four experimental groups assigned to five dietary inclusion levels making a total of twenty experimental units.

Formulation and composition of experimental diet.

A 40% iso-nitrogenous feed was formulated from the feed ingredients fish meal, soybean meal, yellow maize, vitamin, minerals, palm oil, dicalcium phosphate, starch, lysine and methionine purchased from Gombe feedstuff market, Gombe. The dry ingredients were milled with grinding machine to very fine particle size and sieved. The ingredients were weighed according to the formulation and mixed to homogeneity. Each of the feeds was used to process the five different experimental diets in four groups. Each of the experimental diet group contained black cumin and the inclusions with the experimental diet codes areas shown in table 2. The mixed ingredients were pelleted with a pelleting machine at 0.2mm diameter size; air dried at room temperature, packed in polythene bags, labeled and stored at room temperature in the laboratory until when needed.

Stocking Density

Sixty 50L plastic tanks were used for the experiment indoor. The water level in each tank was maintained at volume of 35 litres throughout the study period. Water in each tank was replaced every three (3) days throughout the period to maintain relatively uniform physiochemical parameters. In order to avoid overcrowding the fingerlings were stocked at a rate of ten fish per plastic bowl of 50 litres each for experimental purpose (Sogbesan *et al.*, 2004).

Fish Husbandry

The experiment was monitored for mortality. Bi-weekly weights were measured using sensitive weight balance (Ohaus, England). Five fingerlings were sampled during the weighing and recorded while lengths were estimated using metre rule calibrated in cm. Fish were fed 5% of the body weight.

Growth Performance Indices

Mean Weight gain (g/fish) = $(W_f - W_i)$.

$$\text{SGR (\%/day)} = \frac{\text{Log } W_f - \text{Log } W_i}{t} \times 100$$

Nutrient Utilization

$$\text{FCR} = \frac{\text{Weight gain (g)}}{\text{Feed intake (g)}}$$

$$\text{PER} = \frac{\text{Mean weight gain (g)}}{\text{Mean protein intake (g of protein in 100g of diet/fish)}}$$

Results

Growth performances and nutrient utilization of *Clarias gariepinus* fed Black cumin diets for three months

There was gradual increase in the growth of *C. gariepinus* fed Black cumin diets (Table 2). The highest and lowest mean weight gain (MWG) 71.60g/fish and 44.11g/fish were recorded in BcD5 and control diets (BcD1) (Table 2). Relative growth rate (RGR) ranged from 778.39 – 1305 %/fish (BcD2-BcD5). Specific growth rate (SGR) ranged from 1.11 – 1.33%/day (BcD2-BcD5). The highest survival of 100% was BcD5 and the lowest was BcD1 (control diet) and BcD3 diets. The highest condition factor K (5.96) was from BcD4 diet and the lowest 4.35 was BcD3 diet. The highest mean feed intake (MFI) was in BcD5 diet (15.50g/fish) and the lowest was 14.12g/fish (BcD1). The highest feed conversion ratio (FCR) was 27.28 (control diet) (BcD1) and the lowest was BcD5 diet (18.20). There were significant difference in control and cumin additive diets ($p < 0.05$).

Discussion

Supplementation of black cumin at 25%, 50%, 75%, and 1000% in this study did affect growth performance in *C. gariepinus*, similar to results with black cumin seed (*Nigella sativa*) in *O. niloticus* (Diab *et al.*, 2008). Also growth improved with *Carum carvi* and *Allium sativum* in *O. niloticus* (Ahmad and Tawwab, 2011) and with *Ocimum basilicum* in *O. niloticus* x *O. aureus* (Dakar *et al.*, 2008). The present study shows that the highest fish growth and feed utilization were obtained at 100% black cumin diet. The growth performance of fish showed that the values of the mean weight gain (MWG) were positive and significant growth occurred in fish fed the black cumin diet and this was a reflection of the superiority of the black cumin diet over the control diets. The implication of this is that fish fed the black cumin diet gave the best result. The most superior diet in terms of mean weight gain MWG and specific growth rate SGR among the black cumin diets was diet (BcD5). The high MWG, SGR, FER, PER, K, survival and low FCR values of fish fed 100% inclusion diet (BcD5) confirmed it with better advantages for growth and efficiency of feed utilization over the rest of the black cumin treated diets and control diet (Balogun *et al.*, 2016) and Adikwu (2003).

Conclusion

This work has revealed that an additive treated diet has nutritive values, which can be compared with other natural additives, and they have good nutrient. The treated diet gave a good growth performance and nutrient utilization; therefore *Clarias gariepinus* fingerlings can be fed on black-cumin additive treated diet without any negative effects to the fish's growth, nutrient utilization and health. Based on these results, the use of bio-additive in fish feeding is recommended to fish farmers and feed industry.

Table 1: Percentage Composition of Ingredients (g/100g diets) with Black cumin Meal for the Feeding Trials

Ingredients (%)	BcD1 (Control)	BcD2	BcD3	BcD4	BcD5
Fish Meal	30.00	30.00	30.00	30.00	30.00
Soybean Meal	33.00	33.00	36.90	36.80	36.70
Yellow Maize	30.00	29.90	29.80	29.70	29.60
Black cumin	0.00	0.20	0.40	0.60	0.80
Dicalcium phosphate	1.00	1.00	1.00	1.00	1.00
Vitamin / Premix	2.00	2.00	2.00	2.00	2.00
Methionine	0.50	0.50	0.50	0.50	0.50
Lysine	0.50	0.50	0.50	0.50	0.50
Palm Oil	1.50	1.50	1.50	1.50	1.50
Salt	0.50	0.50	0.50	0.50	0.50
Starch	1.00	1.00	1.00	1.00	1.00
Total	100.00	100.00	100.00	100.00	100.00

Keys: BcD1= Control (0g/100g of diet), BcD2= 0.20g/100g of diet, BcD3= 0.40g/100g of diet, BcD4=0.60g/100g of diet, BcD5= 0.80g/100g of diet

*Vitamin and mineral mixture (product of HEPOMIX): 12.000.000 IU Vitamin A; 2.000.000 IU Vitamin D3; 10g Vitamin E; 2g Vitamin K3; 1g Vitamin B1; 5g Vitamin B2; 1.5 g Vitamin B6; 10g Vitamin B12; 30g Nicotinic acid; 10g Pantothenic acid; 1g Folic acid; 50g Biotin; 250g Choline chloride 50%; 30g Iron; 10g copper; 50g Zinc; 60g Manganese; 1g Iodine; 0.1g Selenium and Cobalt 0.1g.

Table 2: Growth and Feed Utilization of *Clarias gariepinus* Fingerlings Fed Black cumin Diets for Three Months

Parameters	BcD 1 (Control)	BcD 2	BcD 3	BcD 4	BcD 5	SEM
Mean weight gain (g/fish)	44.11±1.49 ^c	52.09±5.57 ^b	69.53±2.88 ^a	56.89±1.99 ^b	71.60±4.38 ^a	2.07*
Mean initial weight (g/fish)	5.08±0.06 ^b	6.91±1.17 ^a	6.19±0.62 ^{ab}	5.5.3±0.79 ^{ab}	5.58±0.79 ^{ab}	0.454*

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Mean final weight (g/fish)	49.20±1.43 ^c	59.00±4.71 ^b	75.73±3.86 ^a	61.76±2.04 ^b	77.18±3.86 ^a	1.805 [*]
Relative growth rate (%/fish)	868.19±40.29 ^{bc}	778.39±221.92 ^c	1133.41±167.53 ^{ab}	1030.09±157.79 ^{abc}	1305±242.26 ^a	104.09 [*]
Specific growth rate (%/day)	1.17±0.01 ^{ab}	1.11±0.12 ^b	1.29±0.06 ^a	1.25±0.07 ^{ab}	1.33±0.09 ^a	0.047 [*]
K	5.07±0.45 ^{bc}	5.66±0.29 ^{ab}	4.35±0.21	5.96±0.43 ^a	4.87±0.98 ^{bc}	0.314 [*]
Survival (%)	80.00±0.00 ^b	83.33±11.54 ^b	80.00±0.00 ^b	90.00±0.00 ^b	100.00±0.00 ^a	2.981 [*]
Protein intake (g/100g diet/fish)	4.52±0.73 ^b	4.96±0.31 ^{ab}	5.75±0.1 ^{ab}	5.61±0.28 ^{ab}	6.20±0.56 ^a	5.28 [*]
Protein efficiency ratio	9.76±0.00 ^a	10.50±0.00 ^b	12.09±0.0 ^b	10.14±0.00 ^b	11.55±0.00 ^b	0.00 [*]
Mean feed intake (g/fish)	14.12±0.33 ^b	14.60±0.6 ^{ab}	15.14±0.6 ^{ab}	15.59±0.68 ^{ab}	15.50±0.67 ^a	0.308 [*]
Feed Conversion ratio	0.31±0.01 ^a	0.28±0.02 ^b	0.21±0.01 ^c	0.25±0.01 ^b	0.21±0.00 ^c	0.704 [*]

Mean ± Std on the same row with different superscripts are significantly different (P<0.05)^{*}, ^{ns} = not significant (p>0.05), SEM- standard error of mean, BCD – Black cumin diet

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EFFECT OF REPLACING MAIZE WITH MILLET IN THE DIET OF *CLARIAS GARIEPINUS* (BURCHELL 1822) JUVENILES

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ABSTRACT

A research was conducted to determine the suitability of millet as maize replacement in the feed of African Catfish Juvenile for 56 days. Four isonitrogenous diet of 40% crude protein were formulated using Pearson square method. Maize was replaced with millet at 0%, 10%, 20% and 30%. A total of one hundred and twenty juveniles were used. Ten fingerlings were randomly allocated in to (40cm diameter x 60cm depth) plastic bowl to four treatments and were replicated thrice. The fish were fed twice daily and there was changing of water every two days. Result obtained showed significant difference ($P < 0.05$) in Mean Weight Gain (MWG) and Feed Conversion ratio (FCR). However there was no significant difference ($P > 0.05$) in Specific Growth Rate (SGR). Fish fed diet four with 30% millet inclusion had the best Feed Conversion Ratio (FCR) and highest Mean weight Gain among the treatments.

KEYWORDS: Millet, Replacement, Maize, African Catfish.

Introduction

The acceptability and demand for fish in Africa as a cheap source of animal protein is getting high daily. Wild captured fisheries contribute immensely to the most countries (Stanley *et al.*, 2017). River is one of the major contributors of capture fishes in most of the countries FAO (2004). However, world fisheries and aquaculture lately have continue to fill the gap that were already becoming history at the end of 1990s, as the turnout from aquaculture is growing very faster than any other animal based sector, while the captured fisheries production rate is decreasing. Although the prospect for future fish supply in aquaculture has been achieved through policies development (FAO 2004). According to FAO (2006), fish supplies from capture fisheries can no longer meet the growing global demand for aquatic foods. Hence, there is a need for a viable alternative fish production system that can sufficiently meet this demand, and aquaculture fits exactly into this role. As aquaculture production becomes more intensive in Nigeria, fish feed will be a significant factor in increasing productivity and profitability (Akinrotimi *et al.*, 2007). High cost of fish feed ingredients has been the major setback in aquaculture feed industry and by extension, aquaculture itself. According to Moses *et al* (2016) reported that nutrition in Fish feed production is affected by the increase in the cost of ingredient purchase which amount to 80% of the total production cost. (Moses *et al.*, 2016).

Fish feed ingredients used in feed production such as maize which is rich in carbohydrate that provide energy; In recent years, there has been competition to the use of fish feed ingredient by the feed producers and the populace due to increase in growth rate, lucrative nature in fish farming and consumption. Feed ingredient is insufficient and their inclusion in fish feed also increases the production cost of the feed. Maize is used for boiled, drinks, snacks, roasted or consume with peer or coconut which is a delicacy by many people. Unavailability and high cost of maize is affecting the adequacy nature of the feed ingredients. Feed plays a major role in aquaculture industry, the cost of feed tend to increase with the rising competition of maize meal by other sector. (Omovwohwovie *et al.*, 2018; Taiwo *et al.*, 2017). According to Fakunmoju *et al.* (2014), the increasing prohibitive cost of this commodity has brought about another substitute that can

supplement the source of carbohydrate for aquaculture at relatively low cost without altering the wellbeing and growth of the fish.

Millets are a group of highly variable small-seeded grasses, widely grown around the world as cereal crops or grains for fodder and human food. They do not form a taxonomic group, but rather a functional or agronomic one. Millets are important crops in the semi-arid tropics of Asia and Africa (especially in India, Nigeria, and Niger), with 97 percent of millet production in developing countries (Taiwo *et al.*, 2017). The nutrient composition of millet when compared to maize on mass basis, millet is 40% richer in lysine and methionine and 30% richer in threonine, 8%-60% higher in crude protein (Olaniyi and Falaye 2013). However, despite its massive contribution of amino acid, some anti-nutrients like Tannins, phytic acid, and polyphenols are found in pearl millet, the anti-nutritional factor-phytic acid present in millet need to be removed using appropriate processing technique. Several Processing methods like Decortication and soaking has proven to be effective towards lowering the concentration of anti-nutrients in plant based foods for several years. (Mrinal *et al.*, 2021). This study was designed to determine the effect of millets on growth performance and survival of *Clarias gariepinus*.

MATERIALS AND METHODS

Study Area

The experiment was conducted at the Department of Fisheries Technology, Teaching and Research Farm Chaha Campus, Federal College of Animal Health and Production Technology Vom, Jos South Local Government Area of Plateau State.

Experimental Fish and Set Up

A total of one hundred and twenty (120) Juveniles *Clarias gariepinus* were purchased from a reputable farm at Zarmaganda in Jos South, Plateau State. The fish were starved for 48 hours to empty their gastro intestinal tracts before the feeding trail; it was later stocked in to a (40cm diameter x 60cm depth) plastic tank. Initial total lengths and weights of randomly selected Juveniles were recorded for each replicate (Eyo *et al.*, 2004)

Procurement and Processing Of Test Ingredients

The test ingredients Millet, soybean, Fish meal, maize, groundnut cake, Bone meal, lysine, methionine, vitamin /mineral premix and salt were bought from Bukuru Market in Plateau State.

The millet was decorticated manually with the help of mortar and pestles to removal the pericarp (outer covering) of the grains after which it was soaked in water for 12 -18 hours and sundried. All the ingredients were milled separately (Mrinal *et al.*, 2021).

Feed Formulation and feeding trial

Pearson square method of feed formulation was used to formulate four diets having a crude protein of 40 each. The experimental diets contained varying inclusion levels of millet as replacement for maize at 0%, diet two 10%, diet three 20% and diet four at 30%. The ingredients were thoroughly mixed to form dough. The feed was pelletized through 2mm die using pelletizer. To reduce the moisture, the pelleted feeds were oven dried at 50°C until a constant weight was achieved and then packaged in clean, dry plastic containers. Daily fish ratio was calculated based on 5% bodyweight (2.5%) in the morning 8:00am-9:00am and 2.5% in the evening 5:00pm-6:00pm throughout the duration of the experiment with weekly feed adjustment for 8 weeks. The fish were fed two times daily for 56 days. Siphoning of unwanted feed, faeces and topping of water were carried out daily to maintain the water quality.

Proximate analyses were conducted on each of the diets according to AOAC (1990). This was carried out at the Biochemistry laboratory of Federal College of Animal Health and Production Technology (NVRI) Vom.

Table:1 Composition Of Experimental Diet

Ingredients	D1(0%) control	D2 (10%)	D3 (20%)	D4 (30%)
Millet	0.00	3.45	6.90	10.34

Fish meal	31.25	31.25	31.25	31.25
Soyabean	31.25	31.25	31.25	31.25
Maize	34.48	31.03	27.58	24.14
Bone meal	1.00	1.00	1.00	1.00
Premix	0.50	0.50	0.50	0.50
Methionine	0.50	0.50	0.50	0.50
Lysine	0.50	0.50	0.50	0.50
Vitamin C	0.26	0.26	0.26	0.26
Salt	0.20	0.20	0.20	0.20
Total	100	100	100	100

Measurement of Experimental fish

Data collected were used to calculate the growth indices. Specific Growth Rate (SGR), Mean Weight Gain (MWG), Mean Length Gain (MLG) Mean final weight (MFW), Mean Initial Length (MIL) and Mean initial weight (MIW).

RESULT AND DISCUSSION

The results obtained showing the proximate composition of experimental diet in Table 1 while growth and nutrient utilization parameters in Table 2. No significant different ($p>0.05$) was recorded in the mean initial weight of the fish. There was significant different ($p<0.05$) in all the growth parameters tested for. The highest mean weight gain was recorded in diet 4 (222.50 ± 0.14) follows by diet 3 (220.20 ± 7.07) while the least mean weight gain was recorded in diet 1 (199.13 ± 1.56). Similar pattern was observed in mean final length of the fish. Diet 4 and 2 had the highest value of (13.20 ± 0.28) and (13.00 ± 0.70) then followed by diet 1 with the least values of (12.70 ± 0.42) while the Mean initial length was not significantly different ($P>0.05$). However SGR was significantly similar ($P>0.05$).

The results obtained from this work showed that the nutrient content of 30% and 20% millet were effectively utilized for the mean final weight of *C. gariepinus*. This experiment yielded quite acceptable growth results for the millet diet and higher specific growth rate at 20% of the inclusion when compared to the control diet. However the findings in SGR of this study is higher 2.37 ± 0.49 from the report made by Olaniyi and Falaye (2013) on the nutrient improvement of fermented solid state of millet having 0.48, but lower to the research made by Taiwo *et al.* (2017) on the use of millet chaff to replaced maize having the highest SGR of 3.94 at 0%. The maximum FCR obtained in this study is at 30% and 0% which is 0.88 ± 0.13 and 1.16 ± 0.13 the values are in disagreement with the report from Olaniyi and Falaye (2013); Olaniyi and Falaye (2007) who obtained 3.79 at 8% and 3.79 at 40%. The outcome from this study is in concordant with the growth improvement reported by (Taiwo *et al.*, 2017) and it attest to the acceptability and suitability of the diets since there was no record of adverse effects on the growth rate. The SGR from this findings is higher from the report made by (Maurice *et al.*, 2017) on digestibility and growth performance in fingerlings of tilapia *Oreochromis niloticus* fed with diet containing high-carbohydrate ingredients at 30%. The discrepancy in the recent finding could be attributed to difference in weather and method used toward lowering the anti-nutritional factor. Previous works of Fagbenro *et al.* (2010) showed the need to use plant meal in combined form to produce the cheapest and required nutrient for fish and this formed the basis of this research work. Results of this study have indicated that millet at 30% inclusion can be tolerated by African catfish Juveniles without adverse effect on the growth and nutrient utilization.

CONCLUSION

All tested diets were actively fed upon and accepted by *Clarias gariepinus* all through the experimental period. Millet is a cheap source of feed ingredient and it required little or no fertilizer, this make it favorable to replace maize as carbohydrate source in diets of *Clarias gariepinus* at 30% inclusion.

Table 2: Proximate Composition of Experimental Diet

Parameters	D1 (0%)	D2 (10%)	D3 (20%)	D4 (30%)
Moisture	9.10	9.12	9.10	9.17
Ash	9.30	8.79	9.20	9.30
Crude fat	6.47	7.34	6.32	7.20
Crude fibre	5.28	5.31	5.52	5.96
Crude protein	40.10	40.04	39.60	39.32
Nitrogen free extract	29.75	29.4	30.26	29.05

Table 3: Growth and nutrient utilization parameters of *C.gariepinus* juveniles fed on the test Diet

Parameter	Diet 1 (0%)	Diet 2 (10%)	Diet 3 (20%)	Diet 4 (30%)
MIW (g)	10.15±0.9 ^a	10.9±0.5 ^c	10.9 ± 1.5 ^c	10.10 ± 1.6 ^b
MFW(g)	209.30 ± 1.84 ^d	220.70 ± 2.40 ^c	231.10 ± 0.14 ^b	232.60 ± 1.6 ^a
MWG(g)	199.13 ± 1.56 ^b	209.80 ± 1.41 ^{ab}	220.20 ± 7.07 ^{ab}	222.50 ± 0.14 ^a
MIL(cm)	8.39 ± 0.5	8.04 ± 0.3	8.39 ± 0.8	8.40 ± 0.9
MFL(cm)	12.70 ± 0.42	13.00 ± 0.70	12.90 ± 0.42	13.20 ± 0.28
SGR	2.32±0.07 ^a	2.33±0.00 ^a	2.37±0.49 ^a	2.38±0.02
FCR	1.16±0.13 ^b	1.42±0.54 ^a	2.42±0.54 ^a	0.88±0.13 ^c

Key: MIW-initial weight, MFW-Mean Final weight, MWG-Mean Weight Gain, MIL-Mean initial Length, MFL-Mean Final Length, FCR-feed conversion ratio, SGR-specific growth rate.

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ANALYSIS OF GROWTH PERFORMANCE OF *Clarias gariepinus* FINGERLINGS FED WITH COMPOUNDED DIET AND VITAL DIET

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ABSTRACT

A dietary experiment of compounded diet and vital diet were conducted between April and May 2021, in laboratory of the Department of Biological Sciences, Taraba State University Jalingo between June and July 2021, to evaluate the growth performance of *Clarias gariepinus* fingerlings stocked in a 50 litres plastic bowls. Fingerlings of *Clarias gariepinus* were divided into two (2) groups, each with 20 fingerlings per experimental bowl. The fingerlings stocked were of average weight and length (0.4g and 4cm). Fingerlings in bowl A were fed with indigenous compounded diet made from; tiger nut, groundnut cake and pisces bone while, bowl B, were fed with vital diet. Each treatment was replicated twice with 20 fingerlings per replicate. The fingerlings were fed 4% of their body weight twice daily, from 5-6am and 5-6pm. Growth performance was monitored weekly and analysed using analysis of variance (ANOVA). The result showed that fingerlings from bowl A had the best growth performance with mean weight gain (26.37 ± 0.99), growth rate (149.38 ± 5.62 g), specific growth rate (2.28 ± 0.23) and mean growth rate (10.57 ± 0.02) which exceeded fingerlings from bowl B. There was a significance difference ($p < 0.05$) between growth rate and the different diets. Whereas the food conversion ratio (FCR) was not significantly different ($p > 0.05$), compounded diet (2.77 ± 0.09) and vital diet (2.83 ± 0.05). Based on the result of this research it is recommended that fish cultivators can employ the use of compounded diet to substitute the expensive traded pisces diet in order to reduce cost and increase profitability.

Keywords: Growth performance, *Clarias gariepinus*, Fingerlings, Compounded diet, Vital diet.

INTRODUCTION

Pisces are nurtured for diet and for financial development (Atanda, 2012; Iloba 2020). *Clarias gariepinus* is the best aquaculture genus in the globe from natural perception due to its capacity to flourish in varied environment, its distinctive air-breathing characteristic and its capacity to adapt its eating practice rely on the obtainability of diet (Musa *et al.*, 2012).

The most important limitation in the culture of *Clarias gariepinus* is diet, the high cost of imported traded diet, the dearth of indigenous prepared diets that are nourishing and welcoming to pisces and reachable to cultivators (Awotoye and Adesina, 2020). Pisces diet is anticipated to be responsible for at tiniest sixty per cent of the entire amount of genus cultivation (Mustapha *et al.*, 2014). In an attempt to get economical, not luxurious, substitute pisces diet reachable for cultivators, distinct indigenous pisces diet are raised from diverse supplies. This has guided the appearances and propagation of numerous pisces trades in the manufacture and auction of entire types of pisces diet. Pisces development and existence essentially rely on diet consumption, the constitution of diet, eating rate and the capacity of pisces to take in the nutriment (Iloba, 2020).

Pisces nutritionists' goal is manufacturing excellence traded diets for best pisces development and well-being (Yakubu *et al.*, 2015). The achievement of intensive fish cultivation relies on the preparation of pisces diet that comprises the best quantity of protein and energy required for the development of pisces (Sayed *et al.*, 2018). The chief familiar cultivated pisces in Nigerian aquatic cultivation are Tilapia and catfish (Olaniyi *et al.*, 2020). Large number of pisces cultivators' goal is to manufacture shelve sized pisces in a little period;

hence, the selection of diet choices is important in accomplishing this objective (Ofonime *et al.*, 2019). Pisces needs great excellence nutrimental- stable diets for development and realization to marketplace size in the littlest feasible period (Gabriel *et al.*, 2007).

MATERIALS AND METHODS

Experimental Area:

The experiment was carried out in the laboratory of Department of Biological Science Taraba State University Jalingo.

Experimental Design and Procedures:

One hundred and twenty (120) fingerlings of *Clarias gariepinus* were bought from Venny Veterinary Consult Office Mayo-gwoi Jalingo and were transported in the evening around 5-6pm to laboratory Department of Biological Sciences, Taraba State University Jalingo to avoid mortality due to high temperature. The fingerlings were weigh using top loading weighing balance. The standard length of the fingerlings was taken to the nearest centimetre with the aid of a measuring rule. The fingerlings were randomly introduced into two (2) 50 litres plastic bowls, each containing 20 fingerlings per plastic bowl. Each of the plastic bowl was filled with water and the water level was maintained at 2/3 capacity in all the plastic bowls throughout the experiment. The plastic bowls were covered with net to prevent fingerlings from escape. Bowl A fingerlings were fed with compounded diet while bowl B fingerlings were fed with vital diet. Fingerlings of average weight and length (0.4g and 4cm) were stocked to avoid cannibalization, dechlorinated water was used and the plastic bowls was aerated by exposing it to moderate wind. The fingerlings were starved for 24 hours to empty their gut content and prepare them for the experiment. Each treatment has two replicates of 20 fingerlings per replicate. The experimental plastic bowls was drained weekly.

Feed preparation

3 (37.5%) module of tiger nuts was washed, dried, grinded and mixed thoroughly with 3 (37.5%) module of ground nut cake and 2 (25%) module of fish bone. The obtained mixture was cooked to obtain a dough after which it was pelleted and sundried into 1.0mm in the first month and 1.5mm in the second month for feeding the fingerlings.

Feeding and Measurement

The fingerlings in each different experimental plastic bowl were fed 4% of their body weight twice daily, morning (5- 6am) and evening (5- 6pm). Fingerling's measurements were done weekly and fingerlings were removed from the plastic bowls using scoop net. Fingerling's weight was taken using top loading weighing balance while the standard length was taken to the nearest centimetre with the aid of a measuring rule.

Analysis of Growth Parameters:

The growth parameters were analysed considering mean weight gain (MWG), growth rate (GR), specific growth rate (SGR), mean growth rate (MGR) and feed conversion rate (FCR).

Mean Weight Gain (MWG);

The fish weight gain was determined as the difference between the final mean weight of the fish at the end of the experiment and the initial mean weight gain in grams (Castel and Tiews, 1980).

$$MWG = \frac{W_1 - W_0}{N}$$

N : Where W_0 = Initial mean weight ; W_1 = final mean weight; n = No. of fish in tank

Growth Rate (GR); This was computed using equation adopted from Orisamuko (2006),

$$GR = \frac{W_2 - W_1}{t}$$

Where; W_1 = Initial weight, W_2 = Final weight, t = growth period,

Specific Growth Rate (SGR);

This is the mean percentage increase in body weight per day over a given time interval (Brown, 1957).

$$\text{SGR} = \frac{\ln W_1 - \ln W_0}{T} \times 100;$$

Where W_0 = initial mean weight; W_1 = final mean weight; T = time interval

Mean Growth Rate (MGR); This was computed using the equation adopted from Awotoye and Adesina (2020),

$$\text{MGR} = \frac{W_2 - W_1}{0.5t(W_1, W_2)} \times 100;$$

Where; W_1 = Initial weight, W_2 = Final weight, t = Period of experiment in days, 0.5 = Constant

Feed Conversion Ratio (FCR);

The feed conversion ratio is the unit weight of feed given, divided by the live weight of fish (Wilson, 1989).

$$\text{FCR} = \frac{\text{amount of feed fed (g)}}{\text{weight gain by fish (g)}};$$

Statistical Analysis

Analysis of the growth data was done using analysis of variance (ANOVA).

RESULT AND DISCUSSION

The Table below showed that the mean weight gain was higher in fingerlings fed with compounded diet (26.37 ± 0.79 kg) than vital diet (21.60 ± 1.87 kg). Growth rate (GR) was also higher in fingerlings fed with compounded diet (149.38 ± 5.62 g) than fingerlings fed on vital diet (137.69 ± 9.42 g). Specific growth rate (SGR) was also higher in fingerlings fed with compounded diet ($2.28 \pm 0.23\%$) than fingerlings fed with vital diet ($2.06 \pm 0.08\%$). Mean growth rate (MGR) followed the same trend with compounded diet fed fingerlings showing higher value (10.57 ± 0.02 mg) than vital diet (10.45 ± 0.06 mg). Fingerlings fed with compounded diet had better food conversion ratio (2.77 ± 0.09) than vital diet (2.83 ± 0.05).

The result showed that the mean weight gain (MWG), growth rate (GR), specific growth rate (SGR) and mean growth rate (MGR) of fingerlings fed with compounded diet was significantly different from vital diet. The result disagrees with what was reported by Udoye *et al* (2019) that there was no major difference in the effects of traded pisces diet and indigenous prepared pisces diet on the development (length and weight) of the pisces.

The feed conversion ratio is low in fingerlings fed with compounded diet as against fingerlings fed with vital diet. The result agrees with Muchiri *et al.* (2015); Muin *et al.* (2017) and Iloba, (2020). Good diets have a low FCR which allow additional number of pisces to be cultivated in pisces pond because there are fewer litters contaminating the water hence, healthier water characteristics upsurses the stocking capability of the pisces pond.

The good health of the fingerlings in the present study as indicated by the growth indices is in accordance with Sogbesan and Ugwumba, 2008; Torsobor *et al.*, 2019 and Iloba 2020 who opined that the attribute of a diet is the purpose of how healthy the diet meets the nutriment necessity of pisces. The growth performance of fingerlings fed on the two diets is a suggestion that the two diets have met the nutriment necessity of the fingerlings.

The eating covets examined in the fingerlings of *Clarias. gariepinus* fed with the compounded diet can be attributed to the sugariness and nutriment profusion of tiger nut used in the compounded diet, which are; (starch, fat, sugar, and protein), minerals (chiefly phosphorus and potassium), and vitamins E and C (Belewu and Belewu 2007). Tiger nut also comprise about 25 % oil, which are repellent to peroxidation, 50 % digestible carbohydrates, 4 % protein and 9 % crude fibre (Belewu and Belewu 2007). The nutriment constituent of the groundnut cake was suitable for development and growth of the fingerlings while the aroma and taste of the groundnut cake in the compounded diet was attractive to fingerlings. This is in

consonant with Ranjan *et al* (2018) who reported that groundnut cake has crude protein content of 40-45%, and it contains vitamin E, K and B, which is a suitable complement to diet as it is tasty and boosts fingerlings development.

Pisces bone used in the compounded diet constitute minerals like calcium, iron, phosphorus and little quantity of minor element with unrefined protein constituent which are significant elements that help in bone and muscular build up of the fingerlings fed with it. This result is in line with Akabegbejo and Fasakin (2008). The bone was responsible for the pisces aroma of the compounded diet which made the diet appealing to the fingerlings.

CONCLUSION AND RECOMMENDATION

It can be concluded that compounded diet can be used for raising *Clarias gariepinus* in a culture system instead of vital diet without conceding their growth performances. Researchers and pisces cultivators are encouraged to explore further indigenous resources to make pisces diet available in order to reduce expenditure that goes into purchasing of imported traded diets.

Table 1: Mean Growth Performance of Compounded diet and Vital diet

Indices	Compounded diet	Feed (A)	Vital diet (B)
Mean initial weight (kg)	0.50 ± 0.01		0.5 ± 0.01
Mean final weight (kg)	25.87 ± 0.79		20.10 ± 1.67
Mean weight gain (kg)	26.37 ± 0.99 b		21.60 ± 1.87
Growth rate GR(g)	149.38 ± 5.62 b		137.69 ± 9.42
Mean SGR (%)	2.28 ± 0.23 b		2.06 ± 0.08
Mean MGR (mg)	10.57 ± 0.02 b		10.45 ± 0.06
Food conversion ratio (FCR)	2.77 ± 0.09 a		2.83 ± 0.05

Means within the same row with different superscript are significantly different ($P < 0.05$)

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EFFICACY OF DIETARY β - GLUCAN AS NATURAL ADDITIVE ON THE GROWTH PERFORMANCE AND SURVIVAL RATE OF *CLARIAS GARIEPINUS* (BURCHELL, 1822) FINGERLINGS

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ABSTRACT

A study was conducted at the Lay - Joy Fish Farm, Billiri, Gombe State Nigeria to evaluate the efficacy of dietary β - glucan as natural additive on the growth performance and survival rate of *Clarias gariepinus* fingerlings. 300 *Clarias gariepinus* fingerlings with an average weight of $10.00g \pm 0.00$ were randomly distributed into 15 treatment groups. Fish were fed *twice daily at a rate of 5% of the body weight during the first 15 days and 3% afterwards* with different β - glucan additive concentration at 100g feed: 0.5g (BG1), 1.0g (BG2), 1.5g (BG3) and 2.0g (BG4), while the control group (BG0) was 0.00g/100g feed, all a 40% protein diet for 84 days. *Clarias gariepinus* fingerlings fed diet supplemented with β - glucan additive at 1.0g/100g feed showed higher growth performance and survival rate in terms of mean weight gain, specific growth rate and survival rate, it also had the least (best) feed conversion ratio and highest (best) protein efficiency ratio respectively.

KEYWORDS: β -glucan, growth performance, survival rate, *Clarias gariepinus*.

Introduction

β - glucans are sugars found in the cell walls of bacteria, fungi, yeast, algae, lichens and mainly cereal plants such as oats and barleys (Abed Ali and Al-Faragi, 2017). β - glucans are polysaccharides in which the glucose units are linked with β - 1,3 glycosidic bond (Spano *et. al.*, 2017). In cereal plants the basic units of glucose chains in β - glucans are inter - linked by β -1,3 and β -1,4 bonds (Many and Vizhi, 2014) while in microorganisms β - glucans are formed as a result of the linear central backbone of D - glucose linked by β -1,3 position with glucose side branches β -1,6 of various sizes (Spano *et. al.*, 2017). Baker's yeast (*Saccharomyces cerevisiae*) cell wall are one of the most important sources of β - glucans (Many and Vizhi, 2014). The main structural parts of the cell wall in baker's yeast (*Saccharomyces cerevisiae*) are β -1,3 glucans mainly consisting of 30 - 45 % by weight of the cell wall and β -1,6 glucans 5 - 10% which are relatively little but very important in cross linking (Spano *et. al.*, 2017). The application of β - glucans additive from yeast cell wall to fish feed resulted in improved growth and also enhances survival rates in common carp (*Cyprinus carpio*) as reported by Kumar *et al.* (2014) and Nile tilapia (*Oreochromis niloticus*) Ahmad *et al.* (2015). *Clarias gariepinus* is one of the most important freshwater culture - able fish species in Nigeria and is considered to be omnivorous displaying both scavenging and predatory behaviour (Idodo - Umeh, 2003). It is known to have an extremely varied diet consuming fruits and seeds, all types of aquatic invertebrates and small vertebrates, small mammals and even plankton (Skelton 2001). Therefore, this study was carried out to evaluate the efficacy of dietary β - glucan as natural additive on the growth performance and survival rate of *Clarias gariepinus* fingerlings

Materials and Methods

Study Area

The study was carried out at the Lay - Joy Fish Farm, Billiri Local Government Area (LGA), Gombe State Nigeria. Billiri LGA lies within Lat. 9°50'N; 11°09'E and Long. 9.833°N 11.150°E.

Experimental Fish

Three hundred (300) *Clarias gariepinus* fingerlings with an average weigh of 10.00g $\pm$ 0.00 were obtained from Aremu Logistics Fish Farm Kwadon, Yamaltu - Deba LGA, Gombe State. They were fed with 2mm Coppens fish feed containing 40% protein during the acclimatization period of 7 days.

Formulation, Preparation and Proximate Composition of Experimental Diets

The experimental diets contained fish meal, soybean meal, yellow maize meal, groundnut cake meal (GNCM) and additives. All the ingredients were grounded into a fine powder using a hammer mill and sieved by a 0.25mm sieve. Fish meal, soybean meal, groundnut cake meal, yellow maize meal and additives were obtained from commercial suppliers in Gombe, while vitamin/mineral premix, fish oil and chromic oxide were purchased from TTS Integrated Farms Lagos and the β -glucan (β - 1,3/1,6 - D - glucan) powder naturally derived from the Baker's yeast (*Saccharomyces cerevisiae*) obtained from BonAmour Pharmacy Limited Lagos, Nigeria, which was imported from Piping Rock Health Products, Ronkonkoma, New - York, USA. Prior to the feed formulation, proximate composition of these ingredients were determined using the methods of the Association of Official Analytical Chemist, (AOAC, 2005).

Diets were prepared with crude protein (CP) content as calculated according to Pearson's square method at 40% CP for feeding the experimental *Clarias gariepinus*. All the dietary ingredients were grinded and mixed with vitamin/mineral premix, chromic oxide and oil mixture. Water was added gradually until a desirable paste - like consistency was obtained after which the mixture were pelletized through a disc of various sizes and sun - dried. The pelletized feeds were then store in air tight polythene bags, until when required.

Experimental diets were prepared by incorporating β - glucan additives at four graded levels namely 0.5g, 1.0g, 1.5g and 2.0g/100g feed, while diet without β - glucan additive 0.0g/100g feed served as the control diet and were coded as BG0 (0.0g), BG1 (0.5g), BG2 (1.0g), BG3 (1.5g) and BG4 (2.0g) respectively (Table 1). The β - glucan additive in powder form was included at the measured quantity for each diet and were diluted into 100 ml of warm water to form a solution. The solution was sprayed onto the pelleted feed. Fish oil 15ml/kg feed was added to all the experimental diets to reserve the β - glucan additive. The β - glucan additive diets were prepared in one kg each time. The feed was mixed by a feed mixer machine to achieve homogenous mixture, pelleted using a pelleting machine, air - dried and kept at room temperature until feeding. All the diet samples were subjected to proximate analysis for Crude protein, crude lipid, crude fibre, moisture, ash and Nitrogen free extractives (NFE) contents according to (AOAC, 2005), while the gross energy compositions were estimated.

Experimental Design

Fifteen (15) white rectangular plastics tanks of 1000 Litres capacity were used for this study. it contains Five (5) treatments and triplicates groups using the complete randomize design (CRD). Groups were labelled BG0, BG1, BG2, BG3 and BG4, according to the concentration of the β - glucan additive added to the feed diet (0.0, 0.5, 1.0, 1.5 and 2.0g respectively). The plastic tanks were cleaned and filled with water just a little over 1/3 (300 litre) capacity. Twenty (20) *Clarias gariepinus* fingerlings with average weight of 10.00g $\pm$ 0.00 were stocked in each plastic tank in the triplicates groups and were fed twice daily in the morning at 8:00 - 9:00 and evening at 4:00 - 5:00 pm at the rate of 5% of the body weight during the first 15 days and 3% thereafter for a total period of twelve (12) weeks. Unconsumed feed was siphoned out daily in the morning before feeding the fish. Sampling of the fish was carried out in every 14 days using scoop nets to determine growth rate and feed weighed and quantity was adjusted according to changes in the weight gain of the fish. Fish in the various treatment groups were weighed forth nightly using digital weighing scale (model: EL-5KO2). Before the sampling days the fish were starved for 24 hours before the commencement

of the exercise. Water temperature, pH, dissolved oxygen, and ammonia were measured at the beginning of the experiment after which they were measured fortnightly throughout the period of the experiment.

Growth Parameters and Nutrient utilization

Fishes in each tank were sampled fortnightly and individually measured their weight. The growth performance and **nutrient utilization** of the experimental fish was evaluated at the end by calculating mean weight gain (MWG), daily weight gain (DWG), specific growth rate (SGR), survival rate (SR), feed conversion ratio (FCR) and protein efficiency ratio (PER) as described by Stickey *et al.* (2006). Statistical analysis was carried out using Analysis of Variance and Duncan multiple range tests to study the significant differences.

Results and Discussion

Results of the growth performance, survival rate, FCR and PER of the *Clarias gariepinus* fingerlings fed diets with β - glucan additive are showed in Table 3. Highest growth in terms of MWG (192.0), DWG (2.40) and SGR (1.53) was observed in β - glucan incorporated diet at 1.0g/100g feed (BG2) fed *Clarias gariepinus*, compared to BG1, BG3, BG4 and the control (BG0). Similarly, highest survival rate (93.3%) and PER (1.78) and the least (best) FCR (1.40) were recorded in diet BG2. There was significant difference in the experimental groups in terms of MWG, DWG, SGR, survival rate, PER and FCR of treatment diets (Table 2). During the experimental period, the water temperature ranged from 27.76 - 27.88 °C, pH from 7.51 - 7.80, dissolved oxygen from 5.40 - 5.71 mg/l and ammonia from 0.02 - 0.4 mg/L.

Growth performance in terms of MWG, DWG, SGR, SR, and nutrient utilization in terms of FCR, PER was best in the *Clarias gariepinus* fed treatment diet BG2 containing β - glucan additive at 1.0g/100g feed which was in agreement with the findings of Homechaudhuri *et al.* (2016) who reported a similar results when β - glucan additive was added to the diet of *Labeo rohita* fingerling fed at 1.0g/100g feed and Huong *et al.* (2016) who reported same results for *Pangasianodon hypophthalmus* fingerlings fed dietary supplements of β - glucan additive diet at 1g/100g feed than those of the other treatments with β - glucan additive and control diet. The dietary supplementation of β - glucan additive in fish feed has been reported to improve growth performance in fish such as common carp (*Cyprinus carpio*) Kumar *et al.* (2014) and Nile tilapia (*Oreochromis niloticus*) Ahmad *et al.* (2015). This improvement in growth may be related to the main important constituent of the β - glucan additive, vitamins and digestive enzymes (Ahmad *et al.*, 2015), where β - glucan improve nutrients digestibility and/or providing fish with certain essential nutrient. The highest survival rate recorded from all *Clarias gariepinus* fed treatment diets containing β - glucan additive compared to the control diet was in agreement with the findings of Abed Ali and Al-Faragi (2017) who showed that the survival rate of *Cyprinus carpio* fed different β - glucan additive levels was much higher than that of the control diet and Huong *et al.* (2016) who reported that feeding β - glucans to *Pangasianodon hypophthalmus* fingerlings enhanced survival rate when compared with the control diet. The water quality parameters recorded during the feeding trial of the *Clarias gariepinus* fed diets with β - glucan additive are within the recommended range for *Clarias gariepinus* culture. This revealed that β - glucan additive does not have any harmful effect on the culture tanks' water quality.

Conclusion

In conclusion, incorporation of β - glucan additive into the diet of *Clarias gariepinus* at 1.0g/100g feed improves the growth performance and survival rate. The water quality parameters remained within the recommended range for *Clarias gariepinus* culture and were not affected by the β - glucan additive incorporated diets.

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Table 1. Ingredient Percentage and Proximate/Gross Energy Compositions (g/100g) of Experimental Diets with β - glucan Additive

Ingredients (%)	BG0	BG1	BG2	BG3	BG4
Fish meal	20.00	20.00	20.00	20.00	20.00
Soybean Meal	21.50	21.00	21.00	21.00	21.00
GNC Meal	23.00	23.00	22.50	22.50	22.50
Yellow Maize	30.00	30.00	30.00	29.50	29.00
β – glucan	0.00	0.50	1.00	1.50	2.00
Fish Oil	1.00	1.00	1.00	1.00	1.00
Vegetable Oil	1.00	1.00	1.00	1.00	1.00
Starch	1.00	1.00	1.00	1.00	1.00
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Vitamin/Premix	1.00	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50	0.50
Cr ₂ O ₃	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00
Crude protein (%)	40.03	40.05	40.19	40.07	40.09
Crude lipid (%)	5.81	5.86	5.96	5.88	5.90
Crude fibre (%)	2.82	2.91	3.01	2.95	2.98
Moisture (%)	5.70	5.60	5.29	5.66	5.55
Ash (%)	13.16	12.83	12.78	13.10	13.00

Nitrogen - free extract (%)	33.48	33.31	32.24	32.29	32.65
Gross energy (Kcal/kg)	3,530	3,500	3,495	3,576	3,520

Table 2: Growth Performance and Nutrient Utilization of *Clarias gariepinus* Fed β - glucan Additive Diets

Parameters	BG0	BG1	BG2	BG3	BG4
Initial mean weight (IMW) (g/fish)		10.0 ^a	10.0 ^a	10.0 ^a	10.0 ^a
Final mean weight (FMW) (g/fish)		189.0 ^b	191.0 ^b	202.0 ^{ab}	197.0 ^a
Mean weight gain (MWG) (g/fish)		179.0 ^b	181.0 ^b	192.0 ^{ab}	187.0 ^a
Daily weight gain (DWG) (g/day)	2.13 ^b	2.15 ^b	2.40 ^{ab}	2.22 ^b	2.22 ^b
Specific growth rate (SGR) (%/day)	1.49 ^b	1.51 ^b	1.53 ^{ab}	1.52 ^a	1.52 ^a
Feed conversion ratio (FCR)	1.50 ^a	1.48 ^a	1.40 ^b	1.43 ^c	1.43 ^c
Protein efficiency ratio (PER)	1.66 ^b	1.68 ^b	1.78 ^a	1.73 ^{ab}	1.73 ^{ab}
Survival rate (SR) (%)	86.6 ^b	91.6 ^a	93.3 ^{ab}	90.0 ^a	90.0 ^a

Mean on the same row with different superscripts are significantly different (P<0.05)

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GROWTH PERFORMANCE AND NUTRIENT UTILIZATION OF *CLARIAS GARIEPINUS* (BURCHELL, 1822) FINGERLINGS FED DIETARY BETAINE ADDITIVE DIETS

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ABSTRACT

A study on the growth performance and nutrient utilization of *Clarias gariepinus* fingerlings fed dietary betaine additive was investigated at the Lay - Joy Integrated Fish Farm Billiri, Gombe State Nigeria. Betaine was incorporated at 0.0g/100g, 0.25g/100g, 0.5g/100g, 0.75g/100g and 1.0g/100g in a 40% protein diet, basal diet without supplementation of betaine served as control. The experimental diets were fed to *Clarias gariepinus* fingerlings for 84 days in rectangular white plastic tanks (flow - through system). Feed was given twice daily at a rate of 5% of the body weight during the first 15 days and 3% afterwards. *Clarias gariepinus* fingerlings fed diet supplemented with betaine additive at 0.5g/100g feed showed higher growth performance in terms of mean weight gain, specific growth rate, survival rate and better nutrient utilization in terms of least (best) feed conversion ratio and higher (best) protein efficiency ratio.

KEYWORDS: Growth performance; nutrient utilization; *Clarias gariepinus* fingerlings; betaine additive.

Introduction

Betaine, also called trimethylglycine (TMG), glycine betaine, l-cysteine or oxyneurine is the trimethyl derivative of the amino acid glycine, is a naturally occurring compound, which is extensively allocated within numerous plants and animal tissues (Apicella, 2011). As a biological osmoprotectant and source of methyl groups, betaine is engaged in various cytoprotective and metabolically essential pathways in plants, animals, and prokaryotes (Eklund *et al.*, 2005). Betaine is present in large quantities in aquatic invertebrates and sugar beets, but also in wheat, wheat products and lucerne meal (Apicella, 2011). Common sources of betaine are sugar beets and them by - products such as molasses and condensed molasses soluble (Eklund *et al.*, 2005). As a feed additive, betaine is also available in purified form and most commonly added to animal diets in the form of anhydrous betaine, betaine monohydrate and betaine hydrochloride (Eklund *et al.*, 2005). Studies have found that betaine supplementation was effective in improving weight gain, feed intake and feed conversion ratio in fish (Murthy *et al.*, 2016; Abed Ali and Al - Faragi, 2017; Leong - Seng *et al.*, 2019). Betaine, a highly water soluble and therefore diffusible compound, stimulates the olfactory bulb of fish. The effect of the addition of betaine to the diet of common carp (*Cyprinus carpio*) was reported by Abed Ali and Al - Faragi (2017) that a treatment group with 0.25% betaine fed common carp showed highest growth parameters of specific growth rate, survival rate, feed conversion ratio and protein efficiency ratio compared with the other treatments groups. Murthy *et al.* (2016) reported that dietary supplementation of betaine enhanced growth and feed conversion ratio in common carp (*Cyprinus carpio*), which also help to reduce feed wastage while enhancing feed utilization. *Clarias gariepinus* is one of the most important freshwater culture-able fish species in Nigeria and is considered to be omnivorous displaying both scavenging and predatory behaviour (Idodo - Umeh, 2003). It is known to have an extremely varied diet consuming fruits and seeds, all types of aquatic invertebrates and small vertebrates, small mammals and even plankton (Skelton 2001). Therefore, this study was carried out to evaluate growth performance and nutrient utilization of *Clarias gariepinus* fed dietary betaine additive.

MATERIALS AND METHODS

Study Area

The study was carried out at the Lay - Joy Fish Farm, Gombe - Yola Road, Billiri Local Government Area (LGA), Gombe State, Nigeria. Billiri LGA lies within Lat. 9°50'N; 11°09'E and Long. 9.833°N 11.150°E.

Experimental Fish

Three hundred (300) *Clarias gariepinus* fingerlings with an average weigh of 10.00g ± 0.00 were obtained from Aremu Logistics Fish Farm Kwadon, Yamaltu - Deba LGA, Gombe State. They were fed with 2mm Coppens fish feed containing 40% protein during the acclimatization period of 7 days.

Formulation, Preparation and Proximate Composition of Experimental Diets

The experimental diets contained fish meal, soybean meal, yellow maize meal, groundnut cake meal (GNCM) and additives. All the ingredients were grinded into a fine powder using a hammer mill and sieved by a 0.25mm sieve. Fish meal, soybean meal, groundnut cake meal, yellow maize meal and additives were obtained from commercial suppliers in Gombe, while vitamin/mineral premix, fish oil and chromic oxide were purchased from TTS Integrated Farms Lagos and the betaine powder naturally derived from Sugar beets (*Beta vulgaris*) was obtained from BonAmour Pharmacy Limited Lagos, Nigeria, which was imported from Piping Rock Health Products, Ronkonkoma, New - York, USA. Prior to the feed formulation, proximate composition of these ingredients were determined using the methods of the Association of Official Analytical Chemist, (AOAC, 2005). Diets was prepared with crude protein (CP) content as calculated according to Pearson's square method at 40% CP for feeding the experimental *Clarias gariepinus*. All the dietary ingredients were grinded and mixed with vitamin/mineral premix, chromic oxide and oil mixture. Water was added gradually until a desirable paste - like consistency was obtained after which the mixture were pelletized through a disc of various sizes and sun - dried. The pelletized feeds were then store in air

tight polythene bags, until when required. Experimental diets were prepared by incorporating betaine additives at four graded levels namely 0.25g, 0.5g, 0.75g and 1.0g/100g feed. Diet without betaine additive 0.0g/100g feed served as control and coded as BT0 (0.0g), BT1 (0.25g), BT2 (0.5g), BT3 (0.75g) and BT4 (1.0g) respectively (Table 1). The betaine additive in powder form was included at the measured quantity for each diet and were diluted into 100 ml of warm water to form a solution. The solution was sprayed onto the pelleted feed. Fish oil 15ml/kg feed was added to all the experimental diets to preserve the betaine additive. The betaine additive diets were prepared in one kg each time. The feed was mixed by a feed mixer machine to achieve homogenous mixture, pelleted using a pelleting machine, air - dried and kept at room temperature until feeding. All the diet samples were subjected to proximate analysis for Crude protein, crude lipid, crude fibre, moisture, ash and Nitrogen free extractives (NFE) contents according to (AOAC, 2005), while the gross energy compositions were estimated.

Experimental Design

Fifteen (15) white rectangular plastics tanks of 1000 Litres capacity were used for this study. it contains Five (5) treatments and three (3) triplicates using the complete randomize design (CRD). Groups were labelled BT0, BT1, BT2, BT3 and BT4, according to the concentration of the betaine additive added to the feed diet (0.0, 0.25, 0.5, 0.75 and 1.0g respectively). The plastic tanks were cleaned and filled with water just a little over 1/3 (300 litre) capacity. Twenty (20) *Clarias gariepinus* fingerlings with average weight of $10.00\text{g} \pm 0.00$ were stocked in each plastic tank in the three (3) triplicates groups and were fed twice daily in the morning at 8:00 - 9:00 and evening at 4:00 - 5:00 pm at the rate of 5% of the body weight during the first 15 days and 3% thereafter for a total period of twelve (12) weeks as described by Murthy *et al.* (2016). Unconsumed feed was siphoned out daily in the morning before feeding the fish. Sampling of the fish was carried out in every 14 days using scoop nets to determine growth rate and feed weighed and quantity was adjusted according to changes in the weight gain of the fish. Fish in the various treatment groups were weighed forth nightly using digital weighing scale (model: EL-5KO2). Before the sampling days the fish were starved for 24 hours before the commencement of the exercise. Water temperature, pH, dissolved oxygen, and ammonia were measured at the beginning of the experiment after which they were measured fortnightly throughout the period of the experiment.

Growth Parameters and Nutrient utilization

Fishes in each tank were sampled fortnightly and individually measured their weight. The growth performance and **nutrient utilization** of the experimental fish was evaluated at the end by calculating mean weight gain (MWG), daily weigh gain (DWG), specific growth rate (SGR), survival rate (SR), feed conversion ratio (FCR) and protein efficiency ratio (PER) as described by Stickey *et al.* (2006). Statistical analysis was carried out using Analysis of Variance and Duncan multiple range tests to study the significant differences.

Results and Discussion

The proximate composition of the experimental diets fed to *Clarias gariepinus* fingerlings is presented in Table 1. All the diets had about 40% crude protein. The values of crude protein ranged from 40.037% (BT0) - 40.23% (BT2), crude lipid 5.81% (BT0) - 5.98%(BT2), crude fibre 2.82% (BT0) - 2.98% (BT2), moisture 5.26% (BT2) - 5.90% (BT0), ash 12.80% (BT2) - 13.16% (BT0), nitrogen free extract (NFE) 32.23% (BT2) - 33.48 (BT0) and gross energy (GE) 3,480 Kcal/kg (BT2) - 3,530 Kcal/kg (BT0). Similarly, overall, the proximate **and gross energy** compositions of the experimental diets indicate that there was difference between the diets after incorporation of betaine additive. Data on growth performance, survival rate, FCR and PER of the *Clarias gariepinus* fingerlings fed betaine additive diets are given in Table 2. Highest growth in terms of MWG (220.0), DWG (2.61) and SGR (1.60) was observed in betaine incorporated diet at 0.5g/100g feed (BT2) fed *Clarias gariepinus*, compared to BT1, BT3, BT4 and the control (BT0). Similarly, highest survival rate (90.0%) and PER (2.04) and the least (best) FCR (1.22) were

recorded in diet BT2. There was significant difference in the experimental groups in terms of MWG, DWG, SGR, survival rate, PER and FCR of treatment diets. During the experimental period, the water temperature ranged from 27.76 - 27.89 °C, pH from 7.51 - 7.80, dissolved oxygen from 5.40 - 5.71 mg/l and ammonia from 0.02 - 0.4 mg/L.

Growth performance, survival rate, feed conversion ratio and protein efficiency ratio was best in the *Clarias gariepinus* fed treatment diet BT2 containing betaine additive at 0.5g/100g feed which was in agreement with the findings of Leong – Seng *et al.* (2019) who reported a similar results when betaine additive was added to the diet of brown - marble grouper (*Epinephelus fuscoguttatus*) fingerling at 0.5g/kg feed and Ekasari *et al.* (2021) who reported same results in hybrid grouper (*Epinephelus lanceolatus* × *Epinephelus fuscoguttatus*) juvenile fed dietary supplements of betaine additive diets 0.5g/kg feed. The dietary supplementation of betaine (trimethylglycine) in fish feed has been reported to improve growth performance and flesh quality of common carp (*Cyprinus carpio*) at 0.25% Murthy *et al.* (2016) and at 0.5% in hybrid grouper (*Epinephelus lanceolatus* × *Epinephelus fuscoguttatus*) (Ekasari *et al.*, 2021). The incorporation of betaine additive at 0.5g/100g feed in the diet of *Clarias gariepinus* resulted in significant higher weight possibly by improving feed intake and palability through the activation of the cephalic reflex induced by smell and taste of attractive substances in diet (Murthy *et al.*, 2016). The highest MWG, DWG, SGR, PER and the least (best) FCR were recorded from the *Clarias gariepinus* fed treatment diet BT2 containing betaine additive at 0.5g/100g feed, suggesting that the betaine additive have a beneficial effect when added to the diet at optimal level but, below or beyond that level may negatively affect the catabolic activity. The lower FCR and higher PER for *Clarias gariepinus* fed diet with betaine additive at 0.5g/100g feed indicates better feed utilization by the *Clarias gariepinus* fed this diet and is justified by better growth performance exhibited by *Clarias gariepinus* fed this diet. The better growth performance and nutrient utilization parameters exhibited by *Clarias gariepinus* fed betaine additive at 0.5g/100g feed could therefore be attributed to improved nutritive value (better digestibility indices) of the diet possibly due to increase enzyme activity and in fish, PER is a better indicator of nutritional status with respect to dietary protein than FCR (Murthy *et al.*, 2016).

CONCLUSION

Findings from this study indicates that betaine additive incorporated into the diet of *Clarias gariepinus* at 0.5g/100g feed which was the optimal for all parameters, significantly improved growth, survival rate and nutrient utilization, thereby reducing feed wastage. The water quality parameters remained within the recommended range for *Clarias gariepinus* culture and were not affected by the betaine incorporated diets.

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Table 1. Ingredient Percentage and Proximate Compositions (g/100g) of Experimental Diets with Betaine

Ingredients (%)	BT0	BT1	BT2	BT3	BT4
Fish meal	20.00	20.00	20.00	20.00	20.00
Soybean Meal	21.50	21.25	21.00	21.00	21.00
GNC Meal	23.00	23.00	23.00	23.00	23.00
Yellow Maize	30.00	30.00	30.00	29.75	29.50
Betaine	0.00	0.25	0.50	0.75	1.00
Fish Oil	1.00	1.00	1.00	1.00	1.00
Vegetable Oil	1.00	1.00	1.00	1.00	1.00
Starch	1.00	1.00	1.00	1.00	1.00
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Vitamin/Premix	1.00	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50	0.50
Cr ₂ O ₃	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00
Crude protein (%)	40.03	40.08	40.23	40.10	40.12
Crude lipid (%)	5.81	5.88	5.98	5.85	5.90
Crude fibre (%)	2.82	2.91	2.98	2.96	2.93
Moisture (%)	5.70	5.90	5.26	5.50	5.30
Ash (%)	13.16	12.98	12.80	13.10	13.12
Nitrogen - free extract (%)	33.48	32.28	32.23	32.73	32.63
Gross energy (Kcal/kg)	3,530	3,510	3,480	3,501	3,497

Table 2 : Growth Performance and Nutrient Utilization of *Clarias gariepinus* Fed Betaine Additive Diets

Parameters	BT0	BT1	BT2	BT3	BT4
Initial mean weight (IMW) (g/fish)		10.0 ^A	10.0 ^a	10.0 ^a	10.0 ^a
Final mean weight (FMW) (g/fish)		189.0 ^b	191.0 ^b	230.0 ^a	190.0 ^b
Mean weight gain (MWG) (g/fish)		179.0 ^b	181.0 ^b	220.0 ^a	180.0 ^b
Daily weight gain (DWG) (g/day)	2.13 ^b	2.15 ^b	2.61 ^a	2.14 ^b	2.14 ^b
Specific growth rate (SGR) (%/day)	1.49 ^b	1.51 ^b	1.60 ^a	1.50 ^b	1.50 ^b
Feed conversion ratio (FCR)	1.50 ^a	1.48 ^a	1.22 ^b	1.49 ^a	1.49 ^a
Protein efficiency ratio (PER)	1.66 ^a	1.68 ^a	2.04 ^b	1.67 ^a	1.67 ^a
Survival rate (SR) (%)	86.6 ^b	86.6 ^b	90.0 ^a	86.6 ^b	86.6 ^b

Mean on the same row with different superscripts are significantly different ($P < 0.05$)

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EFFECT OF FORMULATED FISH FEED ON THE GROWTH PERFORMANCE OF *Clarias gariepinus* FRY

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ABSTRACT

The study was conducted for 56 days to determine the effect of formulated fish feed on the growth performance of *Clarias gariepinus* fry. Eight hundred (800) *Clarias gariepinus* fry with mean weight of 3.75 ± 0.00 g were used for the study. The fish were divided into five (5) treatments with three replicates in a randomized block design and were fed formulated fish feed. T1 was the control, fed with Coppens fish feed, T2 was fed diet containing 50% crude protein, T3 was fed diet containing 60% crude protein, T4 was fed diet containing 70% crude protein while T5 was fed diet containing 80% crude protein. Results obtained showed that T5 (80% crude protein diet) gave best feed conversion ratio (1.71 ± 0.07) and higher growth in terms of final mean weight (117.70g), mean weight gain (113.95 ± 0.20 g), percentage mean weight gain ($3038.67 \pm 11.32\%$), specific growth rate (6.32 ± 0.02), length (16.50 ± 0.05 cm), condition factor (2.62 ± 0.10) and survival (98.00 ± 0.19) respectively, survival and better feed conversion ratio in catfish fry. Water quality parameters assessed were not significantly different from each other and were within the acceptable range for fish culture. Temperature was between 27.20 ± 0.04 - 27.32 ± 0.02 °C, pH was between 7.24 ± 0.02 - 7.25 ± 0.02 while dissolved Oxygen was between 5.21 ± 0.03 - 5.22 ± 0.03 mg/l respectively. Fish farmers are recommended to adopt the use of higher crude protein (70 – 80%) in the diet of *Clarias gariepinus* in order to achieve better growth performance and food conversion.

KEYWORDS: *Clarias gariepinus*, formulated diets, and fry.

Introduction

Proper growth of fish depends largely on good nutrition and this is more pronounced with fish in enclosure as they require adequate nutrition (Omoruwou and Edema, 2001). This poses a number of challenges to the fish farmer. Firstly, feed ingredients notably fish meal presently in use is expensive (Akinwande *et al.*, 2002, Dada and Akinwande, 2005). Falaye (1992) estimated the feeding cost to be about 60% of the recurrent cost of fish farming, minimizing the profit margin of fish farmers and negating the economic viability of the fish industry (Omoruwou and Edema, 2001). Feed is generally the largest expenditure in semi-intensive and intensive fish culture operations, and protein is the most expensive component of feeds (Zhou *et al.*, 2010). In fish farming, nutrition is critical because fish feed represent 40 – 50% of the total production costs.

MATERIALS AND METHODS

Experimental Site/fish. The experiment was carried out at the Fish farm Unit of the Department of Fisheries Technology, College of Agriculture, Science and Technology, *Clarias gariepinus* fry were purchased from the College fish farm. The fry were allowed to acclimatize for a week before the commencement of the experiment, during which they were fed with commercial feed. At the expiration of the acclimatization, they

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were weighed and sorted into plastic experimental bowls of forty (40) litres capacity at the rate of fifty (50) fry per bowl.

Experimental Design. The experiment was composed of five treatments with three replicates in a completely randomized block design. There was a control, treatment 1 with 50% crude protein diet, treatment 2 with 60% crude protein diet, treatment 3 with 70% crude protein diet, and treatment 4 with 80% crude protein diet. A total of eight hundred (800) fry were used for the experiment. Plastic containers were used for the experiment. 50 fry were stocked in each of the container.

Composition of Experimental Diets

Table 1: Gross Composition of the Experimental Diets

Feed ingredients	Control Commercial (Coppens, 52% CP)	feed 0.1mm	T2 (50%CP)	T3 (60%CP)	T4 (70%CP)	T5 (80%CP)
Fish meal (Clupeids)			66.54	82.16	88.63	78.23
Biscuits trash			26.05	10.43	3.96	14.36
Fish premix			0.5	0.5	0.5	0.5
Methionine			0.2	0.2	0.2	0.2
Lysine			0.2	0.2	0.2	0.2
Vitamin C			0.5	0.5	0.5	0.5
Fish oil			3.0	3.0	3.0	3.0
Binder			2.0	2.0	2.0	2.0
Salt			1.0	1.0	1.0	1.0
Total			100%	100%	100%	100%

*** Composition per kg: Vit. A, 4,800,000 I.U.; Vit. D₃, 800,000 I.U.; Vit. E, 4,800 mg; Vit. K, 800 mg; Vit. B, 600 mg; Vit. B₂, 2,800 mg; Vit. B₃, 4,800 mg; Vit. B₆, 600 mg; Vit. B₁₂, 4 mg; Folic acid, 200 mg; Cobalt, 160 mg; Copper, 1,200 mg; Iron, 9,000 mg; Iodine, 480 mg; Magnesium, 2,730 mg; Manganese, 28,000 mg; Zinc, 20,000 mg.**

Data collection. The weight and length of each fry 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 (± 0.1 cm). The sampling exercises were carried out in the morning before feeding the fish. Any dead fish is quickly removed and recorded to determine survival 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). $DGR = \frac{wf - wi}{t}$

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= $\frac{\text{Total number of fry at the end of the experiment}}{\text{Total number of fry stocked at the beginning of the experiment}} \times 100$

Condition factor. The condition factor of the *Clarias gariepinus* fry fish after the experiment was calculated as: $CF = \frac{W \times 100}{L^3}$ W = Weight (g) L = Length (cm)

Length. This was taken by measuring the total length from the tip of the snout to the end of the caudal fin using a ruler calibrated in centimeters.

Statistical Analysis. All data collected was subjected to one way Analysis of Variance (ANOVA). A comparison of means among diets was carried out by Duncan Multiple Range test (Duncan, 1955) at significant level of 0.05. All computations was performed using statistical package SPSS 18.0 (SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

The result of growth performance of *Clarias gariepinus* fry fed formulated fish feed with varying crude protein levels is presented in Table 2. Result from Anova table shows that the treatments were significantly different ($p < 0.05$) from each other. Fish feed T5 (80 % CP) had the highest mean weight gain of 113.95 ± 0.20 g followed by fish feed T4 (70% CP) with 104.75 ± 0.18 g. The lowest mean weight gain of 89.20 ± 0.04 g was recorded in T1. The results of percentage mean weight gain (%) revealed that the highest percentage mean weight gain of 3038.67 ± 11.32 % was obtained in fish fed T5 (80% C.P. diet), followed by T4 (70% CP) with 2793.33 ± 8.42 %, while the lowest percentage mean weight gain of 2347.37 ± 7.21 % was obtained in fish fed T1. The result showed that there was significant difference ($p > 0.05$) in percentage mean weight gain among the treatments. Specific growth rate (SGR %/g/day) of *Clarias gariepinus* fry fed formulated feed with varying crude protein showed no significant difference among the treatments. However, the highest specific growth rate of 6.32 ± 0.02 %/g/day was recorded in T5 and lowest 5.70 ± 0.04 %/g/day in T1. Feed conversion ratio of fish fed T1 and T3 were not significantly different from each other, likewise T3, T4 and T5 were not significantly different from each other. T1 (control diet) had the highest FCR value of 2.37 ± 0.23 , followed by T2 with 2.03 ± 0.15 , while T5 recorded the lowest FCR value of 1.71 ± 0.07 . Length changes was also not significantly different between T1 and T2 and T4 and T5 respectively but were significantly different from T3. T5 had the highest length of 16.50 ± 0.05 cm and the lowest was T1 with 10.20 ± 0.04 cm. Condition factor showed that T4 and T5 were not significantly different from each other but were significantly different from T1, T2 and T3 respectively. Lowest condition factor of 2.62 ± 0.10 was obtained in T2 and highest (8.76 ± 0.15) in T5. Survival rate showed that T1 and T2 were not significantly different from each other. T5 had the highest survival rate of 98.00 % followed by T4 with 96.00 % and T3 with 94.5 % while the lowest survival rate 89.50 % was obtained in T1 respectively.

Table 2: Growth performance of *Clarias gariepinus* fry fed formulated fish feed with varying crude protein level

Parameters	Crude protein level				
	T1 Control (Coppens, 0.1mm 52% C.P)	T2 (50 %)	T3 (60 %)	T4 (70 %)	T5 (80 %)
IMW (g)	3.80	3.75	3.75	3.75	3.75
FMW (g)	93.00	98.90	101.50	108.00	117.70
MWG (g)	89.20 ± 0.04^e	95.15 ± 0.24^d	97.75 ± 0.13^c	104.75 ± 0.18^b	113.95 ± 0.20^a
PMWG (%)	2347.37 ± 7.21^e	2537.33 ± 6.45^d	2693.33 ± 9.32^c	2793.33 ± 8.42^b	3038.67 ± 11.32^a

SGR (%/g/day)	5.70 ± 0.04 ^a	6.00 ± 0.11 ^a	6.05 ± 0.09 ^a	6.19 ± 0.03 ^a	6.32 ± 0.02 ^a
FCR	2.37 ± 0.23 ^a	2.03 ± 0.15 ^a	1.94 ± 0.04 ^b	1.91 ± 0.12 ^b	1.71 ± 0.07 ^b
Length (cm)	10.20 ± 0.04 ^c	13.13 ± 0.12 ^b	12.00 ± 0.08 ^b	15.36 ± 0.09 ^a	16.50 ± 0.05 ^a
CF	8.76 ± 0.15 ^a	4.37 ± 0.11 ^b	5.87 ± 0.21 ^b	2.99 ± 0.12 ^c	2.62 ± 0.10 ^c
Survival rate (%)	89.50 ± 0.23 ^b	90.00 ± 0.19 ^b	94.50 ± 0.40 ^a	96.00 ± 0.25 ^a	98.00 ± 0.19 ^a

^{a, b, c}Mean with different superscript along the row are significantly different (p>0.05)

IMW = Initial mean weight, FMW = Final mean weight, MWG = Mean weight gain, PMWG = Percentage mean weight gain, SGR = specific growth rate, FCR = feed conversion ratio.

Table 3 present the results of physico-chemical properties of the culture medium. The result revealed that highest temperature value 27.32±0.02 was obtained in T3 while the lowest temperature value of 27.20±0.04 was obtained in T1. pH values was highest (7.25±0.02) in T1 and T3 respectively and lowest 7.22±0.05 in T5. Dissolved Oxygen value was highest 7.22±0.03 in T1, T3 and T4 respectively and lowest T2 and T5 respectively. There was no significant difference in the physico-chemical parameters of the water in which *Clarias gariepinus* fry were cultured.

Table 3: Water quality parameters of the culture water

Parameters	T1	T2	T3	T4	T5
Temperature (°C)	27.20±0.04	27.23±0.06	27.32±0.02	27.31±0.05	27.30±0.05
pH	7.25±0.02	7.24±0.03	7.25±0.02	7.24±0.02	7.23±0.05
DO (mg ⁻¹)	5.22±0.03	5.21±0.03	5.22±0.03	5.22±0.03	5.21±0.01

Growth is an index of energy gains and losses within an environment. Weight gain is one of the important parameters for measuring growth. It is widely reported that protein is the most important and expensive constituent of the feed that should be supplied in adequate amounts to support good growth with minimal cost (Wee and Tacon, 1982; Zehra and Khan, 2011). In the present study, growth of catfish fry was significantly affected by different dietary protein levels. Growth (final mean weight, mean weight gain, percentage mean weight gain, specific growth rate, feed conversion ratio and survival rate) increased at higher dietary crude protein (CP) level. Similar growth trends resulting from varying protein level were observed in earlier studies (Pagni *et al.*, 2008). Inadequate protein amount in a diet of fish depresses its growth due to reduction in the available energy for growth (Farhat and Khan, 2011; Kim *et al.*, 2002). According to a report by Brett and Groves (1979), fish being aquatic obtain sufficient energy from chemical breakdown of proteins than land animals, thus underscoring the importance of protein in the diets of fish (Kpogue *et al.*, 2013). The 80% CP diet gave higher growth, higher mean weight gain, survival and better feed conversion ratio in catfish fry. The crude protein level in this study is higher than the protein requirements recommended for other carnivorous fish fry: 48-53% for *Salmo trutta*; 45- 53% for *Carassius auratus*; 42-56% for *Clarias gariepinus* and *Heterobranchus longifilis*; 50-55% for hybrid catfish *H. bidorsalis* × *C. anguillaris* (Brett and Groves, 1979; Arzelet *et al.*, 1995; Fiogbe and Kestemont, 1995; Kerdchuen, 1992). It is therefore important to formulate fish feeds that satisfy the nutrition requirements of the target fish species, for instance most of the carnivorous fish studied show a relatively high dietary protein requirement in the range of 35-70% (Diyaware *et al.*, 2009). Therefore, the present study, results show that dietary crude protein has a marked influence on growth. Diet with 80% CP had better FCR than diets with lower crude protein contents. A similar trend has also been found by different authors for other freshwater carnivorous fish species including pikeperch, and snakehead (Tucker, 1998; Nyina-wamwiza *et al.*, 2005). Higher pressure on body protein in order to satisfy the dietary needs for tissue building, repair, and metabolism has been suggested as the reason for poor growth and dietary utilization observed in fish fed sub-optimal dietary protein levels (Aliyu-Paiko *et al.*, 2010). This means that fish fed the high-protein diets (80% crude protein) used protein more efficiently than fish fed the lower crude protein diet. Survival rate also increases with increased dietary crude protein level, this means low protein diets might not have met

the nutrition requirements of catfish fry and thereby leading to nutrient-deficient related mortalities (Mohanta *et al.*, 2013; Barton *et al.*, 2002; FAO, 1996).

The water quality parameters of the cultured medium in this study were favourable for fish growth and performance and are within the recommended range for freshwater fish culture. The water temperature observed in this study was between 27.20°C – 27.32°C. These values are within the acceptable range for freshwater fish culture as recommended by National Research Council (1993), who gave the optimum growing temperature for freshwater fish range to be 25-30°C for catfish which grow quickly. Good fish production is the result of many important factors including pH. The result of pH of this study indicated a pH range between 7.22-7.25. The result is in line with the findings of Zweig (1989) who reported that different species have different pH tolerance; however, the generally accepted pH range for fish culture is 6.5-9.0 (Zweig, 1989). According to De Silva and Anderson (1995), fishes have a narrow tolerance of pH so many studies have been focusing on the pH limits at which fish grow and reproduce rapidly.

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COMPARATIVE STUDY ON GROWTH AND FOOD UTILIZATION OF *Heterobranchus longifilis* FED WEEVIL-INFESTED FEED AND CONTROL DIET

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ABSTRACT

This study was conducted to evaluate the effects of weevil (*Sitophilus zeamais*) infested feed on the growth performance and food utilization of *Heterobranchus longifilis*. A total of 120 healthy fingerlings of *H. longifilis* with a mean initial individual body weight of 10.28 ± 1.85 g and mean initial individual total length of 9.16 ± 0.12 cm were stocked at 20 per tank in six (6) tarpaulin tanks measuring 100cm by 80cm by 100 cm and reared for 75 days. Blue Crown feed (42% crude protein) of 2mm size was divided into two groups, group A (control feed – Feed A) and group B (weevil infested feed – Feed B) and fed twice daily to the experimental fishes to satiation. The results obtained showed that growth performance indices were significantly better ($P < 0.05$) in fish fed Feed A than fish fed Feed B. In Feed A length gain was 22.68 ± 1.97 cm, weight gain (4054.74 ± 6.50 g), growth rate (54.06 ± 1.24 g/day), specific growth rate (4.04 ± 0.20 %/day), and mean growth rate (24.21 ± 0.12 mg/day). There was no significant difference ($p > 0.05$) in the percentage survival of fish fed the two experimental feeds. Food intake (7136.34 ± 36.60 g), food conversion ratio (1.76 ± 0.15) and food conversion efficiency (56.82 ± 1.80 %) were significantly better ($P < 0.05$) in fish fed Feed A than fish fed Feed B. Proximate composition of the Feed A was significantly better ($P < 0.05$) than those obtained for Feed B. Based on the findings of this study, weevil infestation in fish feed has a negative impact on the nutritional composition of feed which will negatively affect food intake, food conversion ratio, fish growth and profitability. Therefore, to avoid weevil infestation of feed in feed store, good sanitary and hygienic condition should be maintained constantly.

KEYWORDS: Insect-infested feed, *Heterobranchus longifilis*, growth performance, food utilization; feed store;

Introduction

Heterobranchus longifilis is a species of the African Catfish and belongs to the Clariidae family. It is among most cultivable fish species in Nigerian fish farms because of some favorable physical, biological and organoleptic and economic attributes such as size at maturity, fast growth rate, disease resistance, fecundity, tolerance of varying water quality indices, high stocking densities in captivity, ease of induced breeding, acceptability of artificial feed, good meat quality, nice taste and high market value. The success recorded in the cultivation of this species and other fish species in Nigeria is significantly attributed to fish feed and its quality. According to Eyo *et al.*, (2022), poor management of aquaculture feed such as poor storage of feed in unhealthy and unhygienic conditions is one of the silent or unnoticed threats undermining the growth of Nigerian aquaculture industry. This problem has led to insect infestation on the feed, deteriorating of feed quality, reducing feed stability and feed toxicity. Grain weevil and warehouse beetles are capable of boring through feed bags and sacks, providing holes used as an entry point by other insects and also for air penetration leading to increased moisture level in feed and mold growth (Matovu and Okello, 2010). These insects and pests produce harmful compounds and allergens during their feeding activity which contaminate

the feed (Rajendran and Parveen, 2005) and , farmers still use these insect infested feed to feed their fish to avoid huge monetary loss . Consequently, fish growth, water quality, feed quality, culture duration and profit margin may be negatively affected by the use of weevil-infested feed. Also, these pests could serve as potential vectors for transmission of diseases to fish and human (Matovu and Okello, 2010). Currently, very few studies have been documented on the effects of weevil-infested fish feed on fish including Eyo et al., (2022) who studied the effects of weevil-infested feed on the fecundity and gonad development of the African Catfish (*C. gariepinus*). Therefore, this study was carried out to evaluate the effects of weevil-infested feed on the growth performance and food utilization of *H. longifilis*.

MATERIALS AND METHODS

Experimental design

This study was conducted for 75 days using 6 tarpaulin tanks (100 by 80 by 100 cm) labelled A₁, A₂, A₃, B₁, B₂ and B₃. A total of 120 fingerlings of *H. longifilis* were purchased from a private fish hatchery in Uyo and used for the study. In each of the experimental units, 20 fingerlings were stocked and acclimated for a period of 14 days before the start of the feeding experiment. The fishes were fed to satiation twice daily with commercial feed without weevils. At the start of the experiment, the acclimated fish were starved for 24 hours. Thereafter, the initial wet body weight and length of the fish in each experimental unit were measured using a METTLAR MT-5000D electronic balance to the nearest gram and measuring board respectively Fish in units A₁, A₂ and A₃ were fed Feed A (control feed without weevil) and fish in units B₁, B₂ and B₃ were fed Feed B (weevil-infested feed). The fishes in the experimental units were fed to satiation twice daily 8.00 am and 5.00 pm. Biometric measurements including total length (TL-cm) and total weight (TW-g) were measured fortnightly.

Experimental Feed

In this study, 2 mm size of commercial feed (42 % CP) was used as the experimental feed. The experimental feed was purchased from a fish feed outlet in Uyo, Akwa Ibom State, Nigeria. The experimental feed was divided into two groups (Group A and Group B). Group A was the control feed without weevil infestation and Group B was exposed to weevil infestation.

Weevil collection and introduction

Unsexed adult weevils (*S. zeamais*) of between 1 to 15 days were collected following the method of Eyo *et al* (2022) from grains such as maize infested with weevil and cultured in a plastic bucket containing 5 kg of Blue Crown feed. A total of 200 weevils were introduced into the plastic bucket containing the feed. Muslin cloth and rubber band was thereafter used to screen the bucket to prevent the weevils from escaping. The introduced weevils were allowed to infest the feed for a period of 7 days.

Proximate analysis of experimental diets

The experimental diets were analyzed according to AOAC (2005), in the Faculty of Agriculture Central Laboratory, University of Calabar.

Growth performance indices

Growth performance including weight gain, length increment, growth rate, specific growth rate, mean growth rate, percentage weight gain and food utilization indices including food consumed, food conversion ratio and food conversion efficiency were calculated following the protocols of De Silva and Anderson (1995). Percentage survival was calculated as (Number of fish harvested/ number of fish stocked)*100

Measurement of physicochemical parameters of experimental tarpaulin units

Physicochemical parameters of the experimental units measured weekly throughout the experimental period. Dissolved oxygen (mg/L), pH and water temperature (°C) were the parameters measured. Dissolved oxygen was measured using a Portable Hanna dissolved oxygen meter Model HI9142, pH was measured with a Portable Waterproof pH/EC/TDS Hanna meter (high range) - HI991301, and water temperature was measured with mercury in glass thermometer.

Statistical Analysis

Data was analyzed using Student's T-test statistics with the aid of Predictive Analytical Software (PASW, version 18). Effects with a probability of (P<0.05) was considered significant.

RESULTS AND DISCUSSION

The proximate composition of the experimental diets including crude protein, lipid, moisture, ash, fibre and carbohydrate contents is shown in Table 1.

Results obtained in this study showed that growth performance (Table 2) was significantly better ($P < 0.05$) in fish fed Feed A (control feed) than fish fed Feed B (Weevil-infested feed). In Feed A (Control), length gain was 22.68 ± 1.97 cm, weight gain (4054.74 ± 6.50 g), growth rate (54.06 ± 1.24 g/day), specific growth rate (4.04 ± 0.20 %/day), mean growth rate (24.21 ± 0.12 mg/day) and percentage survival (98.33 ± 0.10 %). In Feed B (Weevil-infested feed), length gain was 17.06 ± 2.05 cm, weight gain (3639.93 ± 12.03 g), growth rate (48.53 ± 0.72 g/day), specific growth rate (3.90 ± 0.27 %/day), mean growth rate (23.59 ± 0.15 mg/day) and percentage survival (96.67 ± 0.10 %). In fish culture, a quality fish feed is expected to supply all the nutrients required by fish for good health, survival and optimal growth performance. According to Sogbesan and Ugwumba (2008), the ability of fish to utilize nutrients in feed, especially protein, imposes a positive influence on its growth rate. The difference obtained in growth performance of the experimental fish may be attributed to the nutritional composition of the two experimental feed as shown clearly in the proximate composition of feeds where values of protein and other indices were negatively affected. Weevil infestation in Feed B significantly ($P < 0.05$) deteriorated the nutritional level which may have resulted to a poor growth compared to the control even though the two feeds were consumed by the experimental fish. Percentage survival (%) of fish fed the two experimental diets did not vary significantly ($P > 0.05$) which implies that the low mortalities recorded in the present study may be attributed to the cannibalistic nature of *H. longifilis* because only the skull of dead fishes were found at the bottom of the tarpaulin tanks during water replacement.

Results obtained in this study showed that feed utilization was significantly better ($P < 0.05$) in fish fed Feed A (control feed) than fish fed Feed B (Weevil-infested). In Feed A (Control), food intake was 7136.34 ± 36.60 g, food conversion ratio (1.76 ± 0.15) and feed conversion efficiency (56.82 ± 1.80 %). In Feed B (Weevil-infested), feed intake was 6988.67 ± 24.90 g, feed conversion ratio (1.92 ± 0.18) and feed conversion efficiency (52.08 ± 1.20 %). Feed intake, feed conversion ratio (FCR) and feed conversion efficiency (FCE) have a direct effect on fish growth and are also used in aquaculture to evaluate feed quality. FCR and FCE has been reported to give a clue on the level of feed acceptability in aquaculture (Eyo et al., 2022). Another factor that maybe responsible for a lower food intake in fish fed Feed B (Weevil-infested feed) is palatability. In aquaculture, palatability critically influences feed acceptability and intake in fishes. According to Eyo et al., (2022), insects infestation in feed may negatively impact on feed through loss or deterioration of feed condition, quality, palatability, odor and taste which may render the feed unacceptable. Feed A (Control) had a more fishy odor than Feed B (Weevil infested) which may be the reason for the increased intake observed in this study.

The mean physicochemical parameters showed that in Tarpaulin Unit A (fed control feed), dissolved oxygen was 4.98 ± 0.02 mg/L, pH (6.93 ± 0.04) and water temperature (29.50 ± 0.05 °C). In Tarpaulin Unit A (fed weevil infested feed), dissolved oxygen was 4.92 ± 0.04 mg/L, pH (6.95 ± 0.03) and water temperature (29.50 ± 0.05 °C). Water quality parameters are important factors that affect fish growth, survival and wellbeing. In this study, water quality parameters including pH, water temperature and dissolved oxygen were within the recommended range for optimal growth and survival of freshwater fishes given by Boyd (1979) and this implies that the significant difference obtained in the growth performance of fish in this study is not attributed to the water quality parameters of the fish tanks.

Table 1: Proximate Analysis of the dry matter of the experimental feed (mg/100 g)

Proximate (%)	Indices	Feed A (Control)	Feed B (Weevil-Infested Feed)

Crude Protein	41.54 ± 0.01 ^a	33.42 ± 0.02 ^b
Lipid	7.96 ± 0.01 ^a	6.09 ± 0.01 ^b
Moisture	5.60 ± 0.03 ^a	6.84 ± 0.02 ^b
Ash	1.82 ± 0.02 ^a	1.91 ± 0.02 ^b
Fibre	3.26 ± 0.01 ^a	3.30 ± 0.02 ^a
NFE	41.13 ± 0.02 ^a	50.12 ± 0.02 ^b

* NFE = Nitrogen free extract. Mean with different superscript are significantly different (P<0.05)

Table 2: Growth performance and food utilization indices of *H. longifilis*

Indices	Feed A (Control)	Feed B (Weevil-Infested Feed)
Initial length (cm)	9.12 ± 0.15 ^a	9.20 ± 0.09 ^a
Final length (cm)	31.85 ± 2.10 ^a	26.26 ± 2.41 ^b
Length gain (cm)	22.68 ± 1.97 ^a	17.06 ± 2.05
Mean initial bulk weight (g/fish)	205.50 ± 2.20 ^a	206.60 ± 1.50 ^b
Mean final bulk weight (g/fish)	4260.24 ± 9.00 ^a	3846.53 ± 12.48 ^b
Mean Weight gain (g/fish)	4054.74 ± 6.50 ^a	3639.93 ± 12.03 ^b
Growth rate (g/day)	54.06 ± 1.24 ^a	48.53 ± 0.72 ^b
Specific growth rate (%/day)	4.04 ± 0.20 ^a	3.90 ± 0.27 ^b
Mean growth rate (mg/day)	24.21 ± 0.12 ^a	23.59 ± 0.15 ^b
Survival (%)	98.33 ± 0.10 ^a	96.67 ± 0.10 ^a
Feed intake (g)	7136.34 ± 36.60 ^a	6988.67 ± 24.90 ^b
Feed conversion ratio (FCR)	1.76 ± 0.15 ^a	1.92 ± 0.18 ^b
Feed conversion efficiency(%)	56.82 ± 1.80 ^a	52.08 ± 1.20 ^b

*Means with the different superscript are significantly different (p<0.05) and values represents the mean and standard error for the triplicate units.

Summary and conclusion

Weevil infestation in fish feed has a negative impact on the nutritional composition of feed and physical characteristics such as feed texture and odor and which will negatively affect food intake, food conversion ratio, fish growth and profitability. To avoid weevil infestation of feed in feed store, good sanitary and hygienic condition should be maintained constantly.

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AQUACULTURE, PROSPECT AND POTENTIALS FOR NIGERIA SUSTAINABLE ECONOMIC GROWTH: A REVIEW

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ABSTRACT

The aquaculture sub-sector has a lot of highly promising potentials, both natural and human resources (land, water and human) and high demand for fish among others are readily available to propel Aquaculture to the status of world leading fish producing countries of the world in Nigeria. Aquaculture is one most important agricultural activity that is immensely contributing to poverty reduction, employment creation, and also capable of ending nutritional deficiencies. Despite its enormous potentials, the sub-sector is however faced by certain constraints especially cost of fish feed, inadequate technical skills, poor fish farming methods, low financing of fish farming projects, inadequate storage and processing facilities, poor quality of brood-stock, market failure among several. This work reviews the prospects and potentials of the sub- sector and the constraints that affect aquaculture in Nigeria.

KEYWORDS: AQUACULTURE, PROSPECT,POTENTIALS, SUSTAINABLE ECONOMIC

Introduction

Aquaculture is simply seen as fish farming, it is the rearing of fish and other aquatic organism under controlled condition such as in pen, ponds, tanks, cages and raceways. The aquaculture industry, which accounts for over 50 percent of global fish production, is the fastest-growing food-producing sector. About 424 aquatic species are cultivated globally, benefiting millions through the provision of nutrition, food security and sustainable livelihood, and poverty reduction (Galappaththi *et al.*, 2020). Globally, it is recognised to play important role in providing food and income in many developing countries. Aquaculture is important for the Nigeria's economic development, considering movement into new fields; expansion of existing fish products, diversification of the sub-sector as the major solution that will put Nigeria economy on the path of growth given the recent fluctuation in global petroleum prices and consequent economic recession in the country (Jerimoth, 2016).

Nigeria spends over one hundred billion naira (N100 billion) annually on fish importation, with current fish demand consumption put at over 2.66 million tonnes per annum, while the present importation rate is over 750,000 metric tonnes (Oota, 2012). These translates that over six hundred million (USD 600) dollars is spent in hard currency and thousands of jobs are exported (USAID, 2010). To meet at least 50% of the global fisheries demand by the year 2030, Aquaculture production has to increase. Nigeria has the required natural resources (aquatic and human resource) and potentials endowed to propel aquaculture development and compete with Asian countries, like Japan (Emmanuel, 2014)

Literature Review

Development of Aquaculture in Nigeria

Nigeria's annual fish demand as at 2012 is 2.66 million metric tonnes with supply at 1.32 million metric tonnes of which local production is 0.62 million metric tonnes while 0.7 million metric tonnes is from importation (Ayinla, 2012). Aquaculture accounts for 200,000 metric tonnes of the total fish supply. Nigeria is a coastal state bordered in the South by the Atlantic Ocean. It has a land mass of 923,766 km², with about 1.75 million hectares of suitable sites for aquaculture development. The aquaculture sub-sector is considered a very viable alternative to meeting the nation's need for self-sufficiency in fish production. This is based on its high reliability in return on investment and low capital intensity, relative to capture fisheries (Ayinla, 2012).

The Federal government in partnership with Japan concerning Fisheries in Nigeria; based on meeting with Ms. Areola Foluke, acting director of Ministry of Agriculture Abuja Nigeria and Naoki Nakazawa, August 22, 2013 had the following expectations; rehabilitation of fishing terminals, management of the fishery terminals, development of marine culture, development of fish feed mills, development of integrated fish farm estate, upgrade of fisheries laboratories toward international standardization, development of artisanal fisheries landing sites, monitoring control and surveillance controls, development of brood-stock bank/gene banks for commercially important fish species, tuna exploitation and development of canning industry, shrimp aquaculture development and fish capacity building (FIN, 2013).

Scope of Aquaculture

The increasing population growth in developing countries like Nigeria has necessitated sector driven initiatives to bridge the gap between demand and supply which gave rise to increased annual demand for food resource. Fish farming in the arid zone of north-eastern Nigeria has not well advanced especially that fish culture are predominantly practised in earth/dugout, concrete and plastics ponds (Ibrahim *et al.*, 2014). According to Daramola *et al.*, (2007), between 1996 and 2003 Ekiti State had an increase in aqua-cultural activities to the tune of 67.25% increase in the number of earthen ponds. While the level of aquaculture in Nigeria will appear to have increased, the spate of aqua cultural development in some state of the federation has not in any way caught up with the growing human population and fish demand. The need for a long-term plan to ensure a sustainable aquaculture production cannot be over-emphasized.

Status of Aquaculture in Nigeria

Aquaculture activities in Nigeria started about 50 years ago, yet Nigeria has not been able to meet domestic production demand for the populace (Olagunju *et al.*, 2007). Nigeria imports over 900,000 metric tons of fish while its domestic catch is estimated at 450,000 metric tons/year (Ozigbo *et al.*, 2013). The current aquaculture production is a far cry from its potential production of 2.5- 4.0 million metric tons (Ayinla, 2012). According to (Ekunwe and Emokaro, 2009), statistics indicate that Nigeria is the largest African aquaculture producer, with production output of over 15,489 tonnes per annum, this is closely followed by Egypt with output of about 5,645 tonnes. Only five other countries: Zambia, Madagascar, Togo, Kenya and Sudan produce more than 1,000 tonnes each. However, according to (FAO, 2012) report, Egypt is highest producer of aquaculture in 2010 with 919,585 tonnes of total Africa production followed by Nigeria with 200,535 tonnes putting their total output to 986,820 tonnes and 221,128 tonnes in 2011 respectively (FAO, 2014).

The Federal government of Nigeria is of late, actively pursuing the development of the fisheries sub-sector in order to cope with the rising demand for fish and fish products and also to diversify its oil-based economy with the aim to achieve self-sufficiency in fish production and ultimately to have fish products available for export. Aquaculture development in Nigeria has been driven by social and economic objectives, such as nutrition improvement in rural areas, generation of supplementary income, diversification of income activities, and the creation of employment. Only recently, aquaculture has been viewed as an activity likely to meet national shortfalls in fish supplies, thereby reducing fish imports. The fisheries sector accounts for about 2% of national G.D.P, 40% of the animal protein intake and a substantial proportion of employment, especially in the rural areas; the sector is a principal source of livelihood for over three million people in Nigeria (Adedeji and Okocha, 2011).

Importance of Aquaculture

Nigeria has a population of about 170 million people, putting its fish demand around 2.66 million metric tonnes, these has positioned aquaculture production on a much stronger market driven path based on commercial production in peri-urban areas (Ekundayo, 2017). Fish farming is a profitable venture; it has the potential to help expand the resource base for food production. For an agrarian based economy like Nigeria, fish farming can generate significant employment, enhance socio-economic status of the farmers as well as generate foreign exchange. The role of aquaculture to the economic development of any nation cannot be over emphasized. About 56million people globally, are directly employed in fisheries and aquaculture and

some 200 million along the value chain. Aquaculture is important in employment generation, poverty reduction and sustainable livelihood, particularly in the rural areas (Jim, 2001). Fish farming can generate significant employment, enhance socio-economic status of farmers, generate foreign exchange, reduce poverty, develop entrepreneurship, and optimize the use of the unexploited resources and self-sufficiency (Oluwasola and Ajai, 2013). About 11 percent (more than 820 million people) of the world's population remain undernourished, up from 10.6 percent in 2015 (FAO, 2019).

Aquaculture Value Addition and Value Chain in Nigeria

Value addition is the added cost of a product from the time the raw material enters the processing plant to the time it leaves; it is also the increase in worth or value of a product after undergoing simple or complex processing operations (De-Silva, 2011). To boost Nigeria's export trade, a deserved attention should be put into the area of processing while meeting the demand and expectation of consumers. For a country to have an increase in its GDP, her net export must be positive. China, Norway, Thailand, Vietnam and USA recorded a positive contribution to their countries GDP through exportation of processed fish in 2012 (FAO, 2014).

Prospects and Opportunities for Aquaculture Development in Nigeria

Nigeria has high potentials for aquaculture development that can be realized substantially through extension services (Adetunji, 2011). The sub sector is the most viable and diverse ground for investment considering the increasing gap between fish demand and supply in Nigeria. The opportunity of bridging the widening gap between demand and supply of fish in Nigeria through domestic production offers a great investment potential to the Nigerian populace and inflow of foreign direct investment into the country (Obiyai and Ekubo, 2011). Opportunities exist in nearly all aspects of the fishing industry, (Ayinla 2012). The following are Some opportunities in Aquaculture; research and training, table size fish production, brood stock production, fish seed production (fish breeding and hybridisation), ornamental fish farming, fabrication, Production of fish handling equipment's and fishing gears, establishment of fish farms, shrimp fishing, production of fish bye products, establishment of fish processing and preservation outlets , fish fingerling production, production system design and construction, capacity building in project management, value addition (Packaging and branding and marketing) and establishment of an ice-melting plant.

It has been projected that Nigeria needs an average annual increase of 3.8% in fish production (Dauda *et al.*, 2018). The Food and Agricultural Organisation, in the year 2000 made a projected population and fish demand and Supply in Nigeria between the years 2000-2025, as indicated in the table below. It was estimated that the population will by 2022 reach 211.40 million, with a corresponding fish demand put at 1.61million tones, however fish supply in this year is 1.40million tone and an estimated shortfall of 0.21million tones.

Socio-Economic Prospects of Aquaculture

A major requirement for social and economic fairness in any given society is food production that is not just enough to feed the populace but excess declared for the export market to generate foreign exchange earnings hence increasing the country's Gross domestic product (GDP). Aquaculture development in Nigeria, has been driven by social and economic objectives, such as nutrition improvement in rural areas, generation of supplementary income, diversification of income activities, and the creation of employment, the National Accelerated Fish Production Programme provides fishing inputs such as engines, gillnets, ropes, lead, and twines to fishermen (Anthony and Richard, 2016). Social status like the sex of an individual plays a very important role in fish farming and agriculture, in terms of property acquisition, for example, fixed assets like land and machines (Olaoye *et al.*, 2013).

Table 1: Projected Population and Fish Demand and Supply in Nigeria (2015-2025)

Year	Population (million)	Fish demand (million tonnes)	Fish supply in domestic production (mT)	Short fall (million tonnes)
2015	173.90	1.32	1.12	0.20
2016	178.80	1.36	1.16	

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	0.20				2017
		183.30	1.39	1.20	0.19
2018		189.00	1.44	1.24	0.20
2019		194.40	1.48	1.28	0.20
2020		199.90	1.52	1.32	
	0.20				2021
		205.60	1.56	1.36	0.20
2022		211.40	1.61	1.40	0.21
2023		217.40	1.65	1.44	0.21
2024		223.50	1.70	1.48	
	0.22				2025
		229.80	1.75	1.52	0.23

Source: FAO (2000)

Over the last 2 decades, Federal Government effort has been on artisanal fisheries development in Nigeria because the fisheries were known to contribute over 95% of the local fish production. The National Scheme (National Accelerated Fish Production Programme), which was introduced by the Federal government through the Federal Department of Fisheries provides fishing inputs such as engines, gillnets, ropes, lead, and twines to fishermen with a 50% subsidy to assist them in attaining maximum capture efficiency (Mathiesen, 2015).

Nigeria has what it takes in terms of resources to compete with world-leading aquaculture nations. Some of these potentials include more than 260 medium and large dams. These dams have a combined storage capacity above 30 billion cubic meters of water. The dams can be used for cage and pen aquaculture. More than 850 km of coastline and maritime water of 210,900 km² include the Exclusive Economic Zone, a narrow continental shelves extending, for only about 15 km in the western area and ranges from 60 to 80 km in the eastern tip. This condition limits the trawl-able grounds to 3200nm² of the 1147nm² continental shelf area. The inshore waters (0–50 m) are characterized by a variety of small fish species varying from 25 to 50 cm in total length (Akinsorotan *et al.*, 2019) 80% of aquaculture production in Nigeria is manned by small-scale farmers, except for few commercial ventures (Deji *et al.*, 2012).

Fish Feed Production as a Prospect in Aquaculture

Many fish farmers use locally produced feed usually stored in large quantities to reduce production costs and increase profit margins. The locally-made feeds are usually from locally available conventional and non-conventional plant and animal wastes like rice, maize, and wheat bran, blood meal, cottonseed cake, and sunflower seedcakes, and soybeans, and cassava. These ingredients can be ground manually and mixed in a hand-operated mixer and then made into pellets using a pelleting machine (Marijani *et al.*, 2019).

Fish Breeding as a Prospect in Aquaculture

Compared to other farm animals fishes have a number of advantages; which includes; high fertility in most species, enabling very accurate evaluation of breeding values by sib or progeny testing and high selection intensities among the brood stock tested, pronounced genetic variability in most traits especially in growth traits, which is significantly higher than in farm animals indicating the chance for high selection response, the extra uterine fertilization, which in combination with the high fertility, is of great advantage for cross-breeding programs, and facilitates gene technology, and the latter being of special importance of fish breeding.

Fish Processing and Marketing Prospect in Aquaculture

Aquaculture products are largely consumed as fresh fish through the available local market and channel, however, a significant portion of these products need to be processed, either through icing or, to a lesser extent, smoking and drying. According to Ward and Singa (2017) fish losses are estimated to be 10 to 12 million tons per year, amounting to 10% of the total capture fisheries.

Sale of freshwater aquaculture products is still a problem in remote areas where the road network is bad, communication is poor, little or no electricity and local demand for fish is limited thereby having a negative effect on selling prices of the produce have a decisive influence on the economy of aquaculture.

According to FAO (2018), fish and fish products currently constitute the most traded food product globally.

Fish by-products Prospect in the Development of Pharmaceutical Industry

The expansion of fish processing has resulted in increasing quantities of by-products, which may represent up to 70 percent of processed fish. Historically, fish by-products were often: thrown away as waste; used directly as feed for aquaculture, livestock, pets or animals reared for fur production; or used in silage and fertilizers. (Al Khawli *et al.*, 2019).

With recent attention tending towards technological advancement, a lot of scientific advancement is channelled toward researches on foreign exchange earnings of fish by-products as supplements of pharmaceutical industries. Many industries reap from the fishery industry by making use of certain by-products obtained-from fish and process them into economic and valuable product for use in production these include; fish wastes such as, fish oil, fish skin/scales/shells and fish bone, are often used in the manufacture of products like, creams, coal oil, soap, fertilizers, amino supplement feed, glue, drug supplement, etc.

Anti-cancer drugs, in particular, have been developed from marine sponges, cyanobacteria and tunicates. Other applications include ziconotide, a powerful painkiller derived from the venom of cone snails, and vidarabine, an antiviral drug that was isolated from a marine sponge (Malve, 2016).

Seaweeds and other aquatic plants have been used as food for centuries in Asia, and they are increasingly gaining attention in many countries elsewhere due to their perception as being an environmentally friendly food that is rich in nutrients, such as iodine, iron and vitamin A (Tanna and Mishra, 2019). Seaweeds e.g (Saccharina latissimi) can be used, generally in dried powder form, for feed additives and cosmetics. In medicine, seaweeds can be used to treat iodine deficiency and as a vermifuge (Marine Biotechnology, 2015). Taikawa (1971) reported that there are a few factories in Japan producing insulin from fish and whales. According to the author, the percentage of insulin in pancreas of tuna is more than that in cattle.

Fish by-products Prospect in the Development of Cosmetics Industry

Fish by-products can serve a wide range of purposes. The shells of bivalves, such as mussels and oysters, can be turned into calcium carbonate or calcium oxide, two highly versatile chemical compounds with wide industrial applications. Other uses for shells include their transformation into cosmetics and traditional medicines (pearl powder), calcium supplement in animal feed (shell powder), handicrafts and jewellery. Other marine organisms are the subject of extensive research because of their potential for the discovery of powerful new molecules (Malve, 2016). Collagen from fish skin and air bladder has gained acceptance in the dentistry application and as artificial skin. Scientific studies on the use of a sustainable exploration of aquatic products and by products like marine collagen are on the increase as an alternative to their mammalian counterparts in use for the production of skin care products. Several aquatic organisms such as marine sponges (Olaoye *et al.*, 2013), jellyfish (Jankangram *et al.*, 2016) have been exploited for the extraction of marine collagen.

In a recent study conducted by Malcorps (2021), fish skin offers potential for extracting collagen and gelatine, as an alternative source to cattle or pigs, furthermore the author stated that "Fish skin also has potential for use as fish leather for the fashion industry."

Fish by-products Prospect in the Development of Food Industry

Food formulation for human consumption especially incorporating fish hydrolysate has been described by Prabhu *et al.* (1975), With their high level of valuable omega-3 fatty acids, feeding by-products to livestock would also contribute to nutrition in the human food chain, and by-products can also be used in pet food too." (Malcorps 2021).

Aquatic Weed/Macro Algae and Its Potentials in Aquaculture

Macro algae are currently the most significant aquatic plant in Nigeria and have contributed to the development of fisheries and the aquaculture industry (FAO, 2016). Nigeria is endowed with about 79 species of seaweed, and the coastlines are characterized by sandy beaches and extensive mangroves, deltas, estuaries and lagoons with correspondingly low algal diversity (John *et al.*, 1997). In a research by Amosu *et al.*, (2013) it showed the potential of macro algae resources for exploitation, culture and utilization for Nigeria, but as yet, no targeted commercial harvesting and cultivation has commenced. Macro algae have been called the medical food of the 21st century (Khan and Satam, 2003).

Integrated Aquaculture Production System its Prospects in Aquaculture

Integrating agriculture and aquaculture can contribute to alleviating food insecurity, malnutrition, and poverty through the provision of high nutritional value for food, income, and job creation reduced production risk, improved access to water, sustainable management of resources and increased farm sustainability (Omofunmi *et al.*, 2017).

The combination of fish culture with crop production and animal husbandry is an environmentally sound farming system that gives an inexpensive source of protein for the rural people, a better farm income, and increased output per small land area and increases the supply of feed for the livestock farming system. Integrated aquaculture in Nigeria is in the form: Livestock - fish integrated systems, Crop - fish integrated systems including rice integrated with the fish system, horticulture integrated with the fish system, sericulture integrated with the fish system, and mushroom integrated with the fish system. There is also the concept of integrated multi-trophic aquaculture-recycling of resources in which discharged nutrients from higher trophic levels become the input to the lower trophic levels (Melaku and Natarajan, 2019).

Problems and Challenges of Aquaculture Development in Nigeria

Nigeria is blessed with numerous opportunities for large-scale aquaculture; however the challenges seem to override these opportunities. Constraints to production in the industry have been identified as recurrent high cost fish feed, poor water quality management, poor quality fish seed, technical know-how etc. Just like every other sector, Aquaculture sub sector is associated with certain challenges that has hindered its development; these include; high cost of input, lack of credit facilities to fish farmers at low interest rate, lack of skilled manpower and lack of aquaculture extension service (Oyinbo and Rekwot, 2013).

The outbreak of diseases is one of the major setbacks in aquaculture production. This leads to economic losses and scarcity of fish and fish products. Diseases due to the presence of bacteria are the main cause of death in aquaculture, particularly in the hatchery, and two factors determining the presence of bacteria in aquaculture are the source of water and the type of feed administered (Jamabo *et al.*, 2019).

CONCLUSION AND RECOMMENDATION

Despite the contributions by the sub sector to employment and National development, it is rarely included in national Agricultural policies. This may be because policy makers often do not have access to data which reflect the importance of fisheries and aquaculture to national development and problems with non-available small-scale fish farming statistics. This review highlighted aquaculture potentials in Nigeria with a view to providing information and make recommendation on prospects for aquaculture development.

Recommendation :

- i. Quick and timely intervention in the subsector is necessary in the areas of planning, resource management, mechanization, post-harvest handling, human resource development that are geared towards reviewing the principles, status, trends, and future needs for investments in fisheries and aquaculture to enhance increased quality production. Thereby increasing the country's GDP, through export trade.
- ii. Introduce robust industrial policy in fish farming to build a synergy between the fish processors and pharmaceutical, cosmetics and fashion industries.
- iii. Government should establish standard demonstration fish farm for training and retraining of farmers and for farmers to replicate, untapped potentials of the fishery sector

- iv. Governmental and Non-Governmental Organisations (NGO) can be effective in motivating small scale fish farmers as well as the large scale producers to improve aquaculture practices by helping them gain access to credit facilities, fish seed inputs as well as modern technology to help improve and boost production.
- v. Individual investors should be encouraged to venture in and tap the un-mined resources in aquaculture.
- vi. More Research should be conducted in the areas of sustainability aquaculture practices

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POTENTIALS OF AQUAPONICS AS A FISH CULTURE SYSTEM IN NIGERIA: A REVIEW

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Abstract

The paper reviews the potentialities of Aquaponics system in Nigeria. The system is an integration of hydroponics and recirculatory aquaculture system, which enables the farmer to grow plants and at the same time culture fish together under efficient water management. Aquaponics system has the potentialities of improving the environmental, social, economy and livelihood of the farmers in a country like Nigeria. The system can also provide employment opportunities and revenue to the government if properly adopted.

Though, the system could face many challenges in Nigeria such as poor and high cost of power supply, lack of expertise and technical know-how among others.

Keywords: Aquaculture; Aquaponics; Hydroponics; Recirculating system

Introduction

The system of aquaponics combines both the recirculatory aquaculture and hydroponic systems in an integrated and symbiotic farming concept which ensures proper recirculation of nutrient efficiently in the system. The system involves the breaking down of the excretory products of the fish by microorganisms and the by-products are then inputted into the hydroponic system for the support and growth of plants (Bosma *et al.*, 2017). As the plant utilizes these metabolites, it purifies the water which in turn is reused in the aquaculture system for fish production (Oladimeji *et al.*, 2020a). The system therefore provides an enabling environment for the growth of crops without or less use of chemicals such as synthetic fertilizers and as well production of fish under minimum cost of water maintenance. Thus, Aquaponics can be regarded more as a sustainable system which make use of both hydroponics (plants) and aquaculture (animals) systems. The system makes use of the natural biological cycles (Nitrification) which allow us to produce fish and plants in a single system with a large reduction in water use (Panigrahi *et al.*, 2016). The major feature of this system includes utilization of waste such that the waste of one system becomes the input of the other system.

The Recirculatory Aquaculture System (RAS) has been adopted to allow the reuse of fish culture water which has been proven to be better and effective in management of nutrients, Nitrogen and solids waste through the process of sedimentation and screen filter than the flow-through system even though, it is not effective in removing fine solids from the system (Dauda *et al.*, 2019). The Aztec Indians may have been one of the first groups to practice Aquaponics before becoming a great empire in Central America. The Aztecs were a nomadic people living near the shores of Lake Tenochtitlan. One of the ways they found for raised plants was by building floating rafts called chinampas on the surface of the lake and plant their vegetables on it. Some remnants of chinampas can still be found today in Central Mexico. The Chinese have used a system of integrated aquaculture in which fish, ducks and plants coexisted in a symbiotic relationship centuries ago (Jim 2014).

Aquaculture as a business venture requires a stable run of the cultivation system and also maintaining all environmental factors under control as well (Ashraf *et al.*, 2015). Recycling, being one of the strategies in minimizing waste, offers three benefits: (i) reduce the demand for new resources; (ii) cut down on transport and production energy costs and (iii) utilizes waste which would otherwise channels to rivers and streams as contaminants (Oladimeji and Isah, 2019). Though the concept of aquaponics has not been well practiced in developing countries especially Africa, the system has a lot of potentialities in terms of economic, environment, livelihood and social sustainability if properly managed. Ajibade and Oyeniyi (2018) stated that power, high cost of investment, technical know-how and Government policies are the major constraints to Aquaponics and other soilless culture systems in Nigeria.

Components of Aquaponics

Subhendu (2015) and Panigrahi *et al.* (2016) describe the major components of aquaponics as followings;

- Rearing tank; this is tank that contains the fish that is been cultured
- Settling basin; is a unit which is meant for catching uneaten food and detached biofilms for settling out fine particulates.
- Biofilter; is a place where the nitrifying bacteria can grow and convert ammonia into nitrates which are usable by the plants.
- Hydroponics sub-system; is the portion of the system where plants are grown by absorbing excess nutrients from the water.
- Sump; the lowest point in the system where the water flows to and from which it is pumped back to the rearing tanks.

Types of Aquaponics

Subhendu (2015) classify the system of aquaponics into five different categories which includes;

- Nutrient film technique (NFT); this system involves a thin film of water and nutrients which are flown through a horizontal pipe or gutter and the plants are suspended above the water. The roots touch the thin film of water and nutrients, thereby taking their nutritional requirement.
- Vertical system; in this system, water is flown directly from fish tank to a column where the plants grows and as the water passes through the column, the roots of the plants absorb their nutrient from the water which then is subsequently pass back to the fish tank. The system involves little or no wastage of water.
- Media based system; this system involves the use of rocks as biological and solid filters. It is designed to use containers filled with rock medium of expanded clay, which are porous to absorb water and air and their seedlings are directly into these. Water is circulated through the containers to allow the plants to absorb/access nutrients before the water is then circulated back to the fish tank.
- Deep water culture system; this system allows plants to float on water surface thereby allowing the roots to hang down into the water. The system consists of long water channels and a deep of 30-40cm with boards that floats on top of the water. The board consists of holes on which the plants are fitted into.
- Wicky bed system; in this system water from the fish tank is fed once a week in a summer through a slotted pipe which allows the water to flow down and slowly wick its way up by capillary action and feed the plants roots from the bottom up.

Status of Aquaponics in Nigeria

Nigeria as a sub-saharan state has been faced with different challenges in terms of water and food availability. There is therefore the need to develop an intensive system of aquaponics which could at the same time address the challenges of water scarcity in aquaculture and again provide an addition source of food from plant materials cultured through hydroponics which is the bases of modern aquacultural system of farming termed AQUAPONICS. Oladimeji *et al.* (2020a) and Dauda *et al.* (2019) describe the system of aquaponics as efficient enough to support plants growth and waste management. According to Ajibade and Oyeniyi (2018), high cost of investment, technical know-how, government policies are the main constraints to the development of aquaponics in Nigeria. More so, it is clear and logical that in situation like Africa, the population significantly lack expertise like R.S.A (S.S.A, 2014). Foods from aquaponics are easily marketed because they are healthier than most other foods including those from field crops hence, there is need to develop a model of intervention to simplify the production of aquaponic system to benefit more people (Mcuhunu *et al.*, 2017). Oladimeji *et al.* (2020b) gave substantial evidence to support the claim that the aquaponics system is more efficient in the production of African catfish and pumpkin compared to other production systems in terms of input cost for optimum performance. Growing fish and pumpkin in the aquaponics system is much cheaper than conventional means of growing them separately in Nigeria. Based on the assumption of Ajibade and Oyeniyi, (2018) aquaponics in Nigeria and other sub-saharan states is poorly developed with little of knowledge added to it. There is information on the commercial scale aquaponics production in Nigeria at the moment.

Potentials of Aquaponics

Aquaponics is a symbiotic combination which was developed to provide a new technique which will be more efficient as a modern farming system. The system has the potentiality to improve in terms of cost, economy and social benefit including fish health management (Oladimeji and Isah, 2019, Panigrahi *et al.*, 2016 and Rizal *et al.*, 2018).

Economic Benefit

Aquaponics as an integrated system has been considered more economical than the unitary fish farming (Daba *et al.*, 2017; Inusah *et al.* 2013 and Oladimeji and Isah 2019). The system even though does not support all crops, Oladimeji and Isah (2019) reported a higher profit margin and Return on investment (ROI) in pumpkin and amarathus than the main fish products, this may be due to little or no fertilizer usage in the process of growing the plants which reduce the total cost of production of the plants. Farmers can also achieve food security, environmental and ecological sustainability from aquaponic system by reducing the level of fertilizer usage (Oladimeji and Isah, 2019). Further afield, the system can intensively produce larger

volume of fish using the conventional RAS which include species of fish that are of high value and at the same time reduce environmental pressure from the aquaculture system (Dauda, 2020).

Social Benefit

The system of aquaponics has been used extensively as a field of study thought in primary, secondary and tertiary level in the educational sector as well as the vocational training centers (Junge *et al.*, 2014; Graber *et al.*, 2014). Even though there is still less comprehensive assessment on sustainability of aquaponics in the urban environment (Junge *et al.*, 2017). The system can still be adopted to train many among the teaming population of unemployed youths in Nigeria to reduce the rate of unemployment and as well to provide a social investment for the future, as Mchunu *et al.* (2017) stated, food security can be achieved via food production in aquaponics, but still there is need to implement and develop a skill development for the system. Chunjie *et al.* (2018) opined that the social potentials of aquaponics include:

- Provision of food security
- Provision of educational facilities
- Serve as a design inspiration
- Source of relatively cheap protein
- Important to low individual income
- Better working condition

Environmental Benefit

Since 1990, there has been a rising issues of great concern on source of pollution from the systems of agriculture, which involve pollution due to nitrates (which are possibly from fertilizer run-off), pesticides, erosion, greenhouse gas emission and biodiversity loses (Mchunu *et al.*, 2017). Aquaponics therefore, has the potential especially in urban areas to check the problem of water and other pollution sources especially those from the aquaculture system. The aquaponics system can therefore significantly reduce the environmental impacts from agriculture through plants production and fish farming (Junge *et al.*, 2017). The environmental benefit of aquaponics may include; reducing food miles and transport emission, use and recycling of water sources, energy consumption and production, recycling of organic waste, new landscape opportunities among others (Chunjie *et al.*, 2018 and Rizal *et al.*, 2018).

Challenges of Aquaponics

Aquaponics system design and application can be considered a highly multidisciplinary approach drawing from environmental, mechanical and civil engineering design concepts as well as aquatic and plant related biology, biochemistry and biotechnology. System specific measurements and control technologies also require knowledge of subjects related to the field of computer science for automatic control systems. This high level of complexity necessarily demands in-depth knowledge and expertise of all involved fields. The biggest challenge in commercial aquaponics is its multi-disciplinarity, needing further expertise in economics, finance and marketing (Goddek *et al.*, 2015)

CONCLUSION

The integration of hydroponics and recirculatory aquaculture system provides a symbiotic relationship between the aquatic animals (fish) and plants. The system provides a modern agricultural technique that provides solution to issues of environmental pollution especially from the fishing sector. Even though aquaponics is not well pronounced in developing countries like Nigeria which may be due to poor and high cost of power supply, government policy and the fact that water is not a major issue to the Nigerian fish industries. Land use policies and law enforcement agencies also focus less on the impacts of waste products from the agricultural sector to the environment in both rural and urban areas of the country due to negligence of the government in law enhancement. The system of aquaponics if properly adopted will not only benefit Nigeria environmentally but also the system can help farmers in improving their source of income and livelihood.

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STRESS AND ITS EXTENUATION IN SHRIMP AQUACULTURE: A REVIEW

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ABSTRACT

Shrimp aquaculture plays a significant role to meet the global food requirement. Shrimp species such as *Litopenaeus vannamei*, *Penaeus monodon*, and *Macrobrachium rosenbergii* are among the most popular food commodities worldwide. However, rearing of shrimps in a man-made environment has resulted in exposure to a number of stressors due to overcrowding, adverse social interactions like competition for food and grazing area, resulting in lowering their metabolic rate, weakening their immune responses, and inhibiting their individual growth rate. It is much easier for diseases to proliferate in monoculture environment than in the wild, where the diversity of the ecosystem provides safeguards against species threatening diseases. Two approaches to mitigate stress in shrimp aquaculture have been described, the first one is non-chemical (biological method) and the other is chemical method. The review covered the concept of stress, antioxidant defence grid in shrimp hepatopancreas and stress extenuation in shrimp aquaculture.

Keywords: Aquaculture, Antioxidant enzyme activities, shrimp, oxidative stress, stress mitigation.

INTRODUCTION

Shrimp aquaculture is the fastest growing animal food producing sectors in the world due to its high demand in developed countries (Kumar *et al.*, 2016). A significant component of the shrimp based protein that humans consume, especially in first world countries, is now provided by this activity. Many species; *Litopenaeus vannamei*, *Penaeus monodon*, and *Macrobrachium rosenbergii* have gone from small-scale regional production to large-scale global production. Concomitant with this rapid growth there also has been the increased occurrence of problems that substantially impacted the profitability of the industry and has been instrumental in shaping the evolution of the shrimp farming, which has failed to realize its potential as a direct result of disease. Lessons from the past show that the global shrimp market has suffered adversely due to the impact of disease outbreaks (FAO, 2020). Stress plays a very important role in susceptibility to disease and the outcome of the disease process. Stress as defined by Bayne (1975) is “a measurable alteration of a physiological steady-state that is induced by an environmental change and that renders the individual more vulnerable to further environmental change.” Increasing stress causes undesirable changes on aquatic animals like oxidative stress which disrupts their cell structure by lipid peroxidation of the phospholipid bilayer as well as causes protein oxidation, modifications in nitrogenous bases of DNA. Antioxidant enzymes like Catalase, Superoxide Dismutase and Glutathione peroxidase as well as HSP70 can serve as biomarkers of stress response in crustaceans (Moruf *et al.*, 2022). The objective of this review article is to focus on stressors and stress mitigation methods in shrimp aquaculture system.

GLOBAL SHRIMP FARMING PRODUCTION

The Global Aquaculture Alliance’s GOAL (Global Outlook for Aquaculture Leadership) 2019 survey depicted global shrimp aquaculture production with reference to different regions in the part of the world over a decade from 2010 to 2021 (Kumar *et al.*, 2022). Figure 1 summarizes estimated global production of shrimps and reported a surge in shrimp production in 2018 which would further escalate through 2021. The global shrimp market faced deterioration due to COVID-19 lockdown but still it was enumerated to be US\$ 18.30 billion in 2020 and is expected to be US\$ 23.4 billion by 2026 (Kumar *et al.*, 2022).

CONCEPT OF STRESS AND STRESSORS

Stress is a normal and natural phenomenon and it is impossible for life to exist without it. In its benevolent form it shapes evolutionary progress and strengthens a species ability to survive. In its malevolent form it weakens animals to the point where their normal physiological processes no longer can protect the host against the onslaught of pathogenic organisms. Stress means the sum of all the physiological response by which an animal tries to maintain or re-establish a normal metabolism on the face of physical or chemical force. Signs of stress can be overt, such as sluggishness, lack of feeding activity, slow growth, molting difficulties, hyperactivity, death, or hidden until animals become ill (Newman, 2000).

The factor that causes stress is called stressors. Rearing of shrimps in a man-made environment has resulted in exposure to a number of stressors, which may not be experienced to the same degree in natural environments. The action of stressors on shrimp is varied and not widely studied. One consistent feature seems to be an elevation in blood glucose levels (Racotta and Palacios, 1998). Measurement of osmoregulatory capacity may also be another useful indicator of the degree of stress that animals are under (Charmantier and Soyeze, 1994) Stressors in aquaculture systems may be categorised as shown in Table 1.

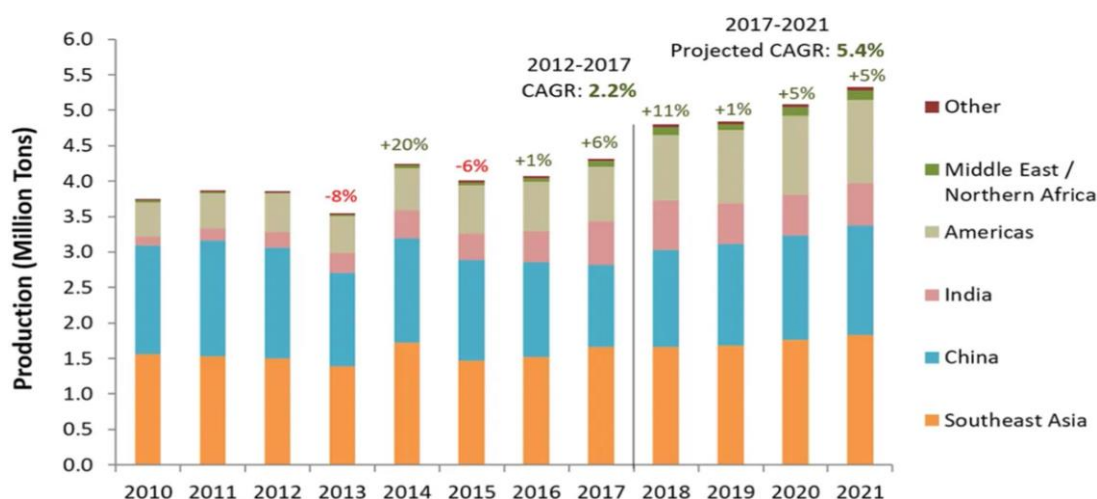


Figure 1: Shrimp farming production by region.

Courtesy-Global Seafood Alliance (Kumar *et al.*, 2022)

Table 1: Stressors in aquaculture systems (Source: Wedemeyer *et al.*, 1999)

S/N	Type of stress	Examples
1	Physical	Temperature, light, dissolved oxygen, sound
2	Chemical	Water quality, pollution, diet, metabolic waste
3	Biological	Stocking density, microorganisms (pathogenic and nonpathogenic), macro-organisms (parasites), lateral swimming space requirements
4	Procedural	Handling, hauling, stocking, disease treatment, feeding methods (manual and automated)

OXIDATIVE STRESS AND ANTIOXIDANT DEFENCE GRID IN SHRIMP

Oxidative stress is a cellular condition which occurs due to physiological imbalance between the levels of antioxidants and oxidants (free radicals or reactive species) in favour of oxidants (Fig. 2). When the production of free radicals exceeds the level which the body's natural antioxidant defence mechanisms can deal with; a cellular oxidative environment is spontaneously generated which elicits the rapid oxidation of essential biomolecules like DNA, protein and lipids, leading to tissue damage followed by system failure and death (Ighodaro and Akinloye, 2018). The major oxidants that can cause oxidative stress to biomolecules are hydroxyl radical (OH); superoxide anion (O_2^-), singlet oxygen radical ($^1O_2$), peroxy radical (ROO), nitric oxide radical (NO) and lipid peroxy radical (LOO) as well as peroxynitrate ($ONOO^-$), trichloromethane ($CHCl_3$) and hypochlorous acid (HOCl) leading to radical induced toxicity (Nath and Halder, 2020).

Oxygen is prone to free radical formation because of its electronic structure which bears two unpaired electrons in separate electronic orbitals. Oxygen radicals such as O_2^- and $^1O_2$ are easily generated from the consecutive reduction of molecular oxygen via step-wise addition of electrons. Hypoxic or/and hyperoxic condition in cells can also produce numerous oxygen-derived radicals. Besides, Sung *et al.* (2014) reported that a couple of therapeutic drugs that enter water bodies through sewage discharge such as acetaminophen and ibuprofen can cause oxidizing effects on cells, consequently leading to formation of oxygen radicals through the activity of drug metabolizing enzymes known as cytochrome P-450 system. Free radicals are mostly produced for advantageous reasons, like they are used for destruction of microbes and pathogens by white blood cells. ROS like O_2^- , H_2O_2 , and OH are produced during phagocytosis (also known as the respiratory burst), which plays an important role in microbicidal activity. However, in excess amounts, oxygen-derived radicals are very detrimental to living beings. Besides being injurious themselves, they are also capable of generating other free radicals like Reactive oxygen species (ROS) and Reactive Nitrogen species (RNS) that are even more fatal (Nath and Halder, 2020).

The shrimp body encloses a complex antioxidant defence system that relies on endogenous enzymatic and non-enzymatic antioxidants. These molecules collectively act against free radicals to resist their damaging effects to vital biomolecules and ultimately body tissues. The role and effectiveness of the first line defence antioxidants which primarily include superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPX) is crucial especially in reference to super oxide anion radical ($\text{O}_2^{\cdot-}$) which is generated under stressful events. This oxidative stress leads to lipid peroxidation, protein oxidation, modifications in nitrogenous bases of DNA (Ighodaro and Akinloye, 2018). To counteract ROS-induced damage of biomolecules, cells have developed levels of defence mechanisms that act to prevent or repair such damage.

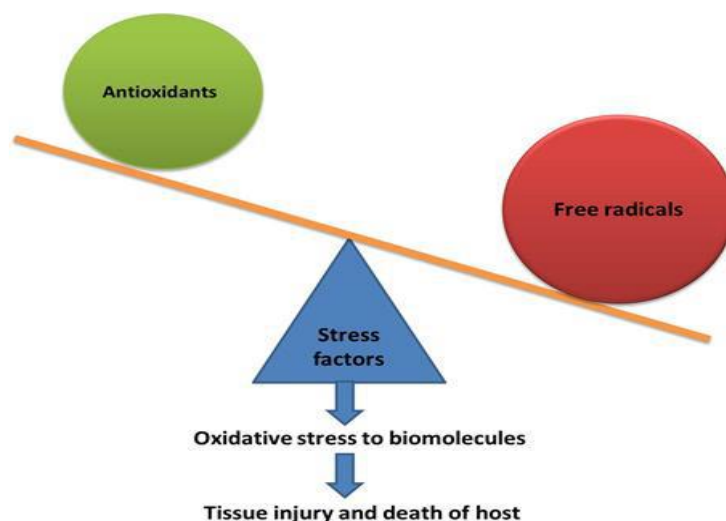


Figure 2: Imbalance between free radicals and antioxidants in biological system (High level of free radicals and low level of antioxidant) (Nath and Halder, 2020)

STRESS EXTENUATION IN SHRIMP AQUACULTURE

One of the most promising areas of research is the development of strategies to reduce the stress during various aquaculture practices. According to Kumar *et al.* (2015), there are two approaches to mitigate stress in shrimp aquaculture, the first one is non-chemical (biological method) and the other is chemical method (Fig. 3). The non-chemical (biological) method includes the entire environmental management, which includes water quality management such as temperature, dissolved oxygen, ammonia, nitrogen, nitrite, salinity, etc., and optimum stocking density, uniform-size stocking, stocking ratio in polyculture, etc. The chemical method includes dietary supplementation of vitamin C, vitamin E and tryptophan and immunostimulants, etc.

Furthermore, prevention and minimization of the myriad of factors that cause and contribute to stress should begin with the selection of sites that are free of agricultural run-off influences and have access to high quality, clean water. Perhaps the most important single aspect is oxygen. Aeration should always be available and ponds should never be allowed to drop below 4-ppm oxygen. Selection and use of genetic stocks of shrimp that can tolerate some of the environmental extremes better than others is necessary, this extends as well to stress tolerance in general. The use of specific dietary additives in the feed can go a long way towards mitigating some of the negative influence when they do occur and the selective use of biologically active compounds to promote heightened immunity during times of stress. Cell wall fractions or whole cell walls from yeast and bacteria have been found to impact the ability of shrimp to tolerate stress, in addition to providing the potential of an immune stimulating effect.

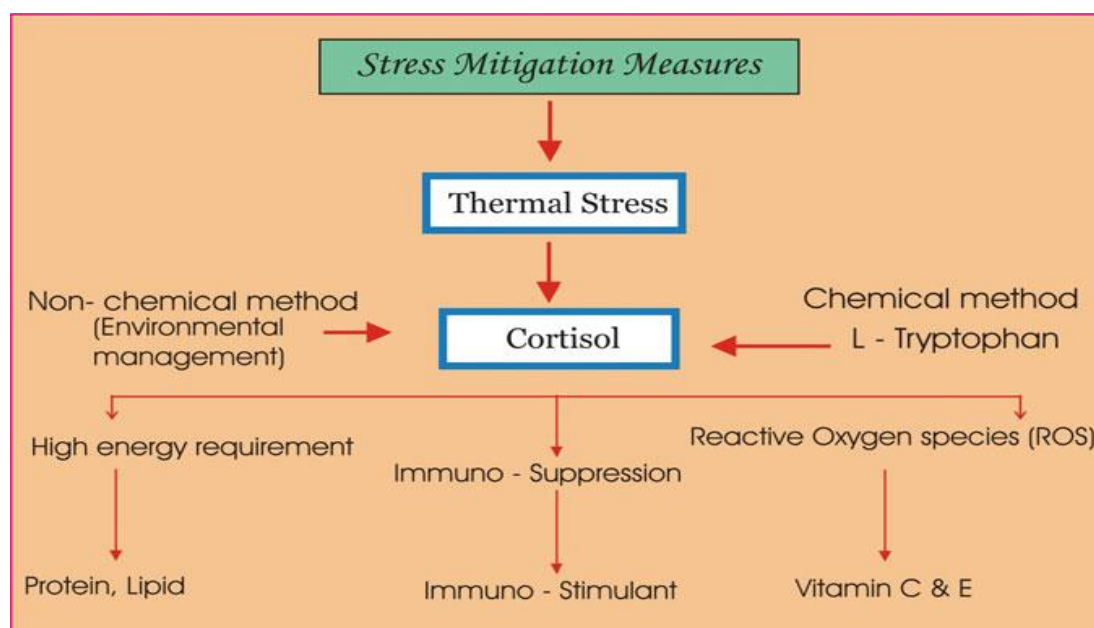


Figure 3: Flow diagram showing stress mitigation measures (Kumar *et al.*, 2015)

CONCLUSION

Shrimp aquaculture is dominated by the marine penaeids, with the tiger shrimp (*Penaeus monodon*) being the most widely cultivated shrimp worldwide. However, rearing of shrimps in a man-made environment has resulted in exposure to a number of stressors due to overcrowding, adverse social interactions like competition for food and grazing area, resulting in lowering their metabolic rate, weakening their immune responses, and inhibiting their individual growth rate. Two approaches to mitigate stress in shrimp aquaculture have been described, the first one is non-chemical (biological method) and the other is chemical method.

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EFFECT OF DUCKWEED (*Lemna minor*) ON HAEMATOLOGICAL PARAMETERS OF AFRICAN CATFISH (*Clarias gariepinus*)

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ABSTRACT

This research was carried out to study growth performance using 40% crude proteins of duckweed (*Lemna minor*) meal as substitute to fishmeal to determine haematological parameters of the African catfish (*Clarias gariepinus*). Four isonitrogenous diets were formulated to contain 0%, 33.3%, 66.7% and 100% duckweed to replace equal weight of fish meal. All the four treatment diets were fed to African catfish (*C. gariepinus*) fingerlings in triplicate for 8 weeks. The best haematological parameter was obtained in fish fed 66.7% duckweed inclusion. Fish fed 100% duckweed (*Lemna minor*) inclusion had the lowest haematological parameters. All the treatment diets showed that haematological parameters due to increasing dietary duckweed meal were significant ($P < 0.05$). The study revealed that the optimum requirement level of duckweed for the improved haematological parameters of *C. gariepinus* was 66.7% duckweed supplementation. It is therefore recommended duckweed at 66.7% inclusion for a successful aquaculture practice due to its high nutrition and improved health status.

Key words: *C. gariepinus*, Haematological parameters, isonitrogenous, Duckweed, diet,

INTRODUCTION

The health of fish has often been reported in terms of the relationship between the weight and length increase. However, there is a need to understand the physiological concept of fish health in relation to blood and the quality of dietary protein fed (Ahmed and Sheikh, 2020). Any changes in the constituent component of blood sample when compared to the normal values could be used to interpret the metabolic state of animal and state of health (Soyinka and Boafo, 2015). Low hematological indices are indications of anemic conditions (Selbel *et al.*, 2021). The aim of this study was to find out the effect of the partial inclusion of duckweed as a supplement in fish feed without compromising the health status of the fish using haematological profiles as indicators of the wellbeing of *C. gariepinus*.

MATERIALS AND METHODS

The study was conducted from January 2022 to February 2022 in the Aquarium of the Department of Biological Sciences, Bayero University, Kano, Nigeria. Four isocaloric and isonitrogenous diets were prepared to contain 0% (control), 33.3%, 66.7%, 100% duckweed to replace equal weight of fishmeal. Prior to processing, the feed ingredients and experimental feeds were ground individually to a fine powder by using hammer mill machine (Sogbesan *et al.*, 2015). The strands were cut into short pieces and sun dried for 3

days to remove moisture. One hundred and twenty (120) mixed sex African Catfish fingerlings (*C. gariepinus*) of average weight 5.40g, average standard length 5.9cm and average total length 7.9cm were obtained from Multifeeds shop opposite BUK old Campus, Kano State, Nigeria (Mamman *et al.*, 2013). Twelve (12) plastic bowls (110 litres) were randomly allocated to four (4) treatment diets in triplicates. The fish were randomly distributed into the bowl (69x45x36cm) at a stocking density of ten (10) fish per bowl. Fresh borehole water was used at the rate of one change per 48hrs throughout the study period (Agatha, 2012). The fish were fed at 5% of their body weight per day, twice daily for 8 weeks. Temperature, pH, dissolved Oxygen total hardness, total Ammonia and nitrite were measured and recorded (APHA, 2016).

Collection of Blood samples and haematological analysis

Prior to the start of the experiment blood samples (1ml each) were collected from the caudal veins of randomly selected four (4) fish from each treatment feeding trials (initial), and 1ml of blood (final) was also collected at the end of the study (8 weeks). The blood was transferred into EDTA tube to prevent coagulation and was analysed in the Department of Human Physiology, Bayero University, Kano. Using the method of Maurice (1982), the total White Blood Cell (WBC) was determined by using (0.05ml) of blood, White blood cell pipette, Turk^S diluting fluid (HCL lysed the red cells), microscope (×40) and the Neubauer counting chamber (Haemocytometer) (Model-XA-40) containing 16 small squares with ruled area (Toma ruling) (A+B+C+D X 100). Red Blood Cell (RBC) was determined by using (0.05ml) of blood, Red blood cell pipette, Hayem^S diluting fluid, microscope (×40) and the Neubauer counting chamber (Haemocytometer) (Model-XA-40) with (5) sets of the small squares (n x 10,000). Packed Cell Volume (PCV) by using a microhaematocrit centrifuge (model AH 132), the blood sample in sealed heparinized (anticoagulant) capillary tube was spun for 15 minutes at 3,000 rpm and read off directly by using microhaematocrit reader. Haemoglobin (HB) was determined by Spectrophotometric technique (SP 360r) where blood (0.02ml), water and ammonia reacted to form Oxyhaemoglobin and the sample was taken into Spectrophotometer for reading. Mean corpuscular volume (MCV) and the Mean Cell Haemoglobin Concentration (MCHC) were calculated using the method described by Maurice (1982) (Table 3). $MCV = \frac{PCV}{RBC} \times 10$

Where : PVC= Packed Cell Volume

RBC = Red Blood Cell Count (Maurice, 1982).

$$MCHC = \frac{\text{Haemoglobin (HB) g\%}}{\text{Haematocrit (PCV)}} \times 100 \text{ (Maurice, 1982).}$$

Statistical Analysis

The results obtained were subjected to one way analysis of variance (ANOVA) test by using the computer Statistical Package for Social Scientists (SPSS-15) windows and where Significant Difference were indicated, means were tested by Turkey test at the 5% level of Significance (Ahmed and Sheikh, 2020).

RESULTS AND DISCUSSION

As Shown in Table 3, the highest Packed Cell Volume (PCV) value was obtained treatment III ($34 \pm 1.48\%$), the minimum Packed Cell Volume (PCV) ($31 \pm 1.50\%$) was obtained in treatment IV. The greatest Final Mean Haemoglobin (HB) value was obtained in treatment III (10.60 ± 0.24) and the least mean Haemoglobin value was obtained in treatment IV (10.10 ± 0.21). The highest Final Mean Red Blood Cell (RBC) value was obtained in treatment III (3.9 ± 0.04) and minimum Red Blood Cell (RBC) value (3.7 ± 0.03) was recorded in treatment IV. The highest Final Mean White Blood Cell (WBC) value was obtained in treatment III (9.20 ± 0.02) and the least White Cell Volume (WBC) was recorded in treatment IV (9.00 ± 0.03). The highest Final Mean Corpuscular Volume (MCV) result obtained in this study was in treatment III (87.24 ± 4.60) and the minimum Mean Corpuscular Volume (MCV) was obtained in treatment IV (83.70 ± 4.21). The highest Final Mean Corpuscular Haemoglobin Concentration (MCHC) value was obtained in treatment I (32.81 ± 0.42), then treatment II and III (31.21 ± 0.33). The results of Means Corpuscular Haemoglobin Concentration (MCHC).

All the Haematological Parameters obtained in treatments I, II and IV in this study were observed to be significantly difference ($P < 0.05$) with treatments III (66.7%). The results of Haematological parameters obtained in this study were in agreement with those reported by Eyiwumiet *et al.*, (2018) who fed Moringa (*Moringaoleifera*) leaves to *C. gariepinus* and Agatha (2012) who fed Garlic (*Alium sativum*) to *C. gariepinus*. There were no significant difference ($P > 0.05$) between the Initial and Final Haematological parameters values obtained in this research and the values recorded for both were within the ranges for good health *C. gariepinus* (Omitoyin, 2006). The results of the Packed Cell Volume (PCV) obtained in this work were higher than those reported by Orire *et al.*, (2021) who fed *Moringa oleifera* full-fat seed meal to *Clarias gariepinus*, but slightly lower than those reported by Awolu *et al.*, (2021) who fed Soybean Meal with Cocoyam Leaves (*Colocasia esculenta*) Meal to African Catfish (*Clarias gariepinus*). The difference could be due to differences in the species or it may be due to environmental factors. The results of the Red Blood Cell (RBC) obtained in this study were in conformity with those reported by Ayo-Olalui and Eze (2021) who fed Yam (*Dioscorea spp*) Leaf Meal to African catfish (*Clarias gariepinus*); Mamman *et al.* (2013) who fed calabash (*Lagenaria vulgaris*) seed to *C. gariepinus*. The Red Blood Cell (RBC) of an organism determines the carrying capacity of dissolved Oxygen. The results of Red Blood Cell (RBC) obtained in this study were lower than those reported by Eyiwumiet *et al.*, (2018) who fed Moringa (*Moringa oleifera*) leaves to *C. gariepinus*. There was significant different ($P < 0.05$) among the treatment feeding trials in terms of Red Blood Cell (RBC) results obtained in this study. The results of Haemoglobin (HB) obtained in this research were similar with those reported by Mamman *et al.* (2013) who fed calabash (*Lagenariavulgaris*) seed to *C. gariepinus*. Packed Cell Volume (PCV) and Haemoglobin (HB) are major and reliable indicators of various sources of stress and these parameters decreases in the presence of anti-nutritional factors. The results of White Blood Cell (WBC) obtained in this study were in agreement to those reported by Awolu *et al.*, (2021) who fed Soybean Meal with Cocoyam Leaves (*Colocasia esculenta*) Meal to African Catfish (*Clarias gariepinus*)., but higher than those reported by many researches (Omitoyin, 2006; Agatha, 2012; Orire *et al.*, 2021). This may be due to better utilization of *Lemna minor* by the fish and different environmental conditions.

Similar observation was reported by Mamman *et al.* (2013) who fed Calabash (*Lagenariavulgaris*) seed to *C. gariepinus*. Lymphocytes are the most numerous cells comprising the leucocytes which function in the production of antibodies and chemical substances serving as defensive against infection. The results of Mean Corpuscular Volume (MCV) obtained in this study were not significantly difference ($P > 0.05$) among the different treatment diets. Similar trend was reported by Ayo-Olalui and Eze (2021) who fed Yam (*Dioscorea spp*) Leaf Meal to African catfish (*Clarias gariepinus*). The results of the Final Mean Corpuscular Haemoglobin Concentration (MCHC) obtained in this study were not significantly difference ($P > 0.05$) with those of the Initial Mean Corpuscular Haemoglobin Concentration (MCHC). This observation was in conformity with those reported by Eyiwumiet *et al.*, (2018) who fed Moringa (*Moringaoleifera*) leaves to *C. gariepinus*. The results of Haematological parameters obtained in this study revealed that *C. gariepinus* can be fed up to 100% inclusion levels of Duckweed (*Lemna minor*) meal without negative effect on the health status of the fish.

Table 1: Proximate Composition of Duckweed (*Lemna minor*) Used in the Study

Composition parameters	% Crude
Crude Moisture	12.70
Crude Protein	36.17
Crude Fibre	11.71
Ether extract (Fat)	10.72
Crude Ash	22.58

Table 2: Percentage Composition of Experimental Diets (as Fed) in Different Treatments Feeding Trials

Treatments	I	II	III	IV
Ingredients	0% (Control)	33.3%	66.7%	100%
White Maize	25	25	25	25
Fish Meal	23	15	8	0
Soya Beans	47	47	47	47
Duckweed	0	8	15	23
Wheat Middlings	1.5	1.5	1.5	1.5
Mineral premix	1	1	1	1
Vitamin premix	1	1	1	1
Vegetable oil	0.5	0.5	0.5	0.5
Bone meal	0.5	0.5	0.5	0.5
Salts	0.5	0.5	0.5	0.5
Total (%)	100	100	100	100

Table 3: Mean Haematological Parameters of *Clariasgariepinus* Fed Duckweed (Lemna minor) Meal

Treatments	I	II	III	IV
Parameters	0% (Control)	33.3%	66.7%	100%
Initial Mean PCV	28.8± 1.52 ^a	28.7±1.50 ^a	28.8±1.40 ^a	28.8±1.35 ^a
Final Mean PCV%	32.0±1.50 ^a	33.0±1.54 ^a	34.0±1.48 ^a	31.0±1.40 ^a
Initial Mean HB	9.7±0.20 ^a	9.6±0.22 ^a	9.7±0.25 ^a	9.6±0.24 ^a
Final Mean HB g/100ml	10.50±0.22 ^a	10.30±0.20 ^a	10.60±0.24 ^a	10.10±0.21 ^a
Initial Mean RBC	3.7±0.04 ^a	3.6±0.05 ^a	3.6±0.03 ^a	3.7±0.04 ^a
Final Mean RBC 10⁶/μl	3.8±0.02 ^a	3.8±0.03 ^a	3.9±0.05 ^a	3.7±0.03 ^a
Initial Mean WBC	8.90±0.01 ^a	9.02±0.02 ^a	8.97±0.04 ^a	8.97±0.04 ^a
Final Mean WBC × 10³/μl	9.10±0.03 ^a	9.10±0.02 ^a	9.20±0.04 ^a	9.00±0.05 ^a
Initial Mean MCV	77.8±4.20 ^a	79.7±4.11 ^a	80.0±3.84 ^a	77.8±3.90 ^a
Final Mean MCV	84.2±4.02 ^c	86.8±4.60 ^b	87.2±4.24 ^a	83.7±4.21 ^c
Initial Mean MCHC	33.7±0.50 ^a	33.5±0.41 ^a	33.7±0.30 ^a	33.3±0.40 ^a
Final Mean MCHC	32.8±0.42 ^a	31.2±0.33 ^b	31.2±0.40 ^b	32.6±0.3 ^a

Means in rows with the same Superscripts are not significantly different (P<0.05)

Keys: % (percentage); PCV: (Packed Cell Volume); Hb: (Haemoglobin); RBC: (Red Blood Cell count); WBC: (White Blood Cell count); MCHC: (Mean Corpuscular Haemoglobin Concentration); MCV: (Mean Corpuscular Volume)

Conclusion

This study revealed that at 66.7% duckweed inclusion meets the requirement for improved growth of *C. gariepinus* without any negative effects on the haematological parameters and health status of the fish. Cheap and locally available duckweed feed supplement is recommended to promote growth with healthy haematological parameters of *C. gariepinus*.

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GROWTH PERFORMANCES OF *Clarias gariepinus* (BURCHELL, 1822) JUVENILES FED HYDROLYZED POULTRY FEATHER MEAL DIETS

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ABSTRACT

The study was carried out to evaluate nutrient utilization and growth performance of *Clarias gareipinus* juveniles fed Hydrolyzed Poultry Feather Meal as alternative for animal protein with other sources of plant protein for 56 days. Five Isonitrogenous diets containing varying levels where Diet 1, (0 %) served as control; Diet 2, (25 %); Diet 3, (50 %); Diet 4 (75 %) and Diet 5 (100 %) were fed to three replicate of *Clarias gariepinus* with a mean weight of 28.59g± 0.45g. The data were analyzed using one-way analysis

of variance (ANOVA) for growth performance, water quality parameters, mineral composition and economic analysis. Duncan's Multiple Range Test was used to compare the mean differences significant at $P < 0.05$. Diet 2, (25 %) had the best growth response and feed utilization ($p > 0.05$) as it had the highest value of weight gain, feed conversion ratio, mean final weight gain and Specific Growth Rate. Diet 2 (25 %) also had the highest value ($P > 0.05$) for Protein Efficiency Ratio and condition factor while gross initial weight across the treatments was not significantly different ($p > 0.05$) from other treatments. Mineral analysis revealed that sodium had the highest concentration in the fish samples of treatment 3 (50 %) and also recorded the least concentration in copper which is not significantly different across all the treatments. Water quality parameters were monitored biweekly for optimum maintenance of the fish throughout the experiment. The cost benefit analysis showed that there was no significant difference in the net profit value and estimated investment cost. It was concluded from this study that the diet with 25% can replace 75% of fish meal if poultry feather meal is processed appropriately through hydrolysis.

Keywords: *Clarias gariepinus*, feather meal, acceptability, growth performance

INTRODUCTION

Feed is known to be a major determinant of successful growth and intensification of aquaculture production. Low availability, poor quality and high costs of feeds is one of the most important factors inhibiting the development of commercial and non-commercial aquaculture in Africa (Hecht, 2007). Fish feeds constitute 40-60% of the total cost of aquaculture production which is expensive and led to extensive studies on replacing a costly fish meal in the diets (Rola and Hasan, 2007).

Feather meal is one of the poultry by-products which contain high protein content (80-85%) and commercially available. With some chemical treatments, it can be a good source of the Sulphur-containing amino acids (Bertsch and Coello, 2005). Besides, the cost of feather meal is approximately two thirds the costs of other animal proteins in the market and it is readily available from any sources (Bishop *et al.*, 1995). In order to increase the availability of animal feed, support the improvement of aquaculture production to meet the demand for animal protein, and to improve national food security by increasing the population from better nutrition an alternative technology is to be able to utilize poultry feathers as raw material for fish feed and processing it into a quality product, poultry feather meal (Winiati, 2008).

The most commonly cultured species of fish in Nigeria includes: Catfish (*Clarias gariepinus*), tilapia (*Oreochromis niloticus*) and crab (*Cyprinus carpio*). Many farmers focus on catfish as they are hardy and can survive different culture systems and diverse environments, grow very fast, has low bone content, high fecundity, improved survival of fry and adapts to supplemental feed, (Adediran, 2002). Catfish has superior value of two or three more times that of tilapia. They estimate that 60% of the fish consumed and is increasingly contributing to the market which till date remains a live fish market (FAO, 2004). *Clarias gariepinus* occupies a unique and prominent position in commercial fisheries in Nigeria because of its ability to be tasty, hardy as well as tolerant to poor water conditions. It is also capable of reproducing in captivity and growing to a size of about 7.0 kg which has an efficient feed conversion ratio in the males and as such attracts high market price (Idodo-Umeh, 2003). This study aim at evaluating the growth performance of *Clarias gariepinus* juveniles fed hydrolyzed poultry feather meal.

MATERIAL AND METHODS

Experimental site

The study was carried out at the Department of Fisheries and Aquaculture Research Farm, Federal University Wukari, Taraba State. The site is located along 7.8°N latitude and 9.0°E longitude of the southern guinea savanna zone of Nigeria and it is situated at elevation 189 meters above the sea level (Blench, and Moore, 2008).

Source and collection of poultry feathers

Poultry feathers were collected from Sabo-Kasua market in Wukari LGA, Taraba state, Nigeria. The town lies on longitude 7°51'N and latitude 9°47'E and it is characterized with three (3) distinct seasons ranging

from harmattan season (November - February), hot/ dry season (March – May) and the rainy season (June – October). The temperature hovers from 25 °C to 28 °C, with a relative humidity close to 52% and an annual rainfall ranging from 1624 – 2004mm.

Processing of poultry feather

The poultry feathers were washed thoroughly with clean water to remove impurities, pressed to reduce the water, boiled in a pressure cooker at 120°C for 120 minutes. The cooked feather is squeezed to drain excess water, air cooled, oven dried at 60°C for 48 hours in a thermostatic oven in Central Laboratory, Federal University Wukari, Taraba State. The poultry feather was milled to pass through a 200 mm screen and packaged in a polythene bag to prevent fungal attack.

Chemical analysis/ proximate analysis

The hydrated poultry feather meal was analyzed for moisture content, ash content, ether extract, crude fiber, crude protein and nitrogen free extract as described by *Nchuma and Obeagu, (2018)*.

Mineral determination in fish

The mineral compositions of the samples were determined using Atomic Absorption Spectrophotometric for calcium, sodium, potassium, copper and iron by AOAC, (2005).

Experimental and Formulated feed

The feeds ingredients such as (Maize, Groundnut cake, Fishmeal, Soyabean meal, lysine, methionine e.t.c) were bought from Gboko main market. The ingredients were milled using hammer milling machine (FAMSUN/ SFSP5 brand), accurately measured and thoroughly mixed with hot water to form homogenized dough, each diet were pelleted to small size of 2mm using a manual hand pelletizer (Afrimash brand), then sun dried and bagged in separate polythene based on inclusion levels of and labeled appropriately.

Fish Collection and Acclimatization

Two hundred (200) healthy Cat fish *Clarias gariepinus* juveniles of 28.59 ± 0.45 g mean weight were purchased from Anointed Farm in Gboko, Benue state, Nigeria. The fish were transported in 50L half-filled plastic jerry cans with water very early in the morning between the hours of 7:00am – 10:00am to the experimental site, Federal University Wukari Research Fish Farm, Taraba state. The experimental fish were acclimatized for two weeks under natural day and night photo-period in a fiber tank (1000 Liters) where fish were fed 5% body weight with Coppens 2 mm twice daily (8:00am and 4:00pm) and water was changed every other day to avoid pollution by fish exudes and unconsumed feed and faeces as recommended by Oyelese and Faturroiti (1995).

Experimental Setup and design

Completely Randomized Design (CRD) was used to set up this experiment. Fifteen (15) plastic bowls (50 litres) were used (3 plastic bowls/ experimental diet) each containing de-chlorinated water providing suitable environment for the fish. Ten (10) juveniles of *Clarias gariepinus* were stocked randomly in the plastic bowls. The set up was covered with mesh to prevent fish from jumping out. Water replacement was done every 3 days using a flow through system. This was to eliminate faecal matter and unutilized feed by fish.

Feeding, Weighing and Measuring of fish

Experimental fish was fed 5% body weight twice every morning and evening (8:00am and 4:00pm) as recommended by Marinmuthu *et al.*, 2010. The following diets were varied as D1 (0%) which was the control, D2 (25%), D3 (50%), D4 (75%) and D5 (100%) with 3 replicates.

The mean weight of fish was determined using an electric sensitive weighing balance (NBT-B1000 MODEL). Mean weight per plastic bowl was recorded after taking the bulk weight of the fish on weekly basis. The mean weight per plastic bowl was taken every fortnight throughout the 12-week period of the experiment. Both standard length and total length of the fish for the experiment were recorded using a

measuring board. Growth performance parameters such as specific growth rate, feed conversion ratio, feed efficiency, feeding frequency and feeding regime were also calculated.

Weight gain (g) = Final weight- initial weight (Falayi, 2009).

$$\text{SGR (g/day)} = \frac{\log \text{ final weight} - \log \text{ initial weight}}{T - t} \times 100 \quad (\text{Aderolu and Sogbesan, 2010}).$$

$$\text{FCR} = \frac{\text{Quantity of feed fed (g)}}{\text{Weight gain (g)}} \quad (\text{Falayi, 2009}).$$

$$\text{PER} = \frac{\text{Mean weight gain(g)}}{\text{Protein consumed}} \quad (\text{Falayi, 2009}).$$

$$\text{Condition factor} = \frac{\text{Final body weight(Wf)}}{\text{Final body length(Lf)}} \times 100 \quad (\text{Amisha et al., 2009}).$$

$$\text{GFCE} = 1/ \text{FCR} \quad (\text{Falayi, 2009}).$$

Determination of water quality parameters

Water parameters were determined throughout the 12-week experimental period (readings were taken bi-weekly). The parameters included water pH which was measured using A Hanna HI 9813-6 pH/EC/TDS/°C, water temperature, was measured using A Hanna HI 9813-6 pH/EC/TDS/°C, dissolved oxygen was measured using MODEL 407510 and water conductivity measured using API test kit.

Economic analysis of experimental diet

The economic analysis was computed to estimate the cost of feed required to raise a kilogram of fish using various experimental diet using the method described by Konyemi *et al.*, (2005).

Estimated investment cost analysis = cost of feed (N) + cost of juveniles stocked

$$\text{Profit index} = \frac{\text{Value of fish (N)}}{\text{Cost of fish (N)}}$$

$$\text{Incident of cost} = \frac{\text{Cost of feed (N)}}{\text{Mean weight gain of fish produced}}$$

Net profit = total cost of fish crop fed (N) – total expenditure

Data analysis

The data collected were analyzed using one-way analysis of variance (ANOVA) for growth performance, water quality parameters, mineral composition results and economic analysis. Duncan's Multiple Range Test was used to compare the mean differences significant at $P < 0.05$.

RESULTS AND DISCUSSION

The result of proximate composition of *Clarias gariepinus* juveniles diet determined for Crude protein, Ash, Crude fibre, Crude lipids, Moisture content and Nitrogen free extract are presented in table 1. The mineral composition in mg/kg of experimental fish, *Clarias gariepinus* is presented in Table 2. The most abundant mineral in the experimental fish samples was Sodium with range values of 30.33 ± 2.01^a to 37.06 ± 2.04^a mg/kg. The values in mg/kg sample of other essential minerals in the experimental fish samples were; potassium ranged between 11.44 ± 1.21^a to 16.23 ± 0.21^a mg/kg sample, Calcium (25.0 ± 1.03^b to 31.41 ± 2.05^a mg/kg) and Iron (0.13 ± 0.01^c to 0.77 ± 0.01^a mg/kg). Calcium is also important in blood clotting, muscles contraction and in certain enzymes in metabolic processes. Magnesium is an important activator of many enzymes system and maintains the electrical potential in nerves. Coefficient of variation percent (CV %) levels of all the minerals were also relatively close. The proximate composition of the ingredients in this study was significantly different with the estimated proportion as shown in Table 1. The protein content of the diets was near as proteins although FTM 75% had the highest percentage, while FTM 100% had the lowest protein percentage. Also from the proximate composition results, it was found out that feed with higher inclusion

levels of feather meal had significantly lower protein content. The results showed that the fish were utilizing their body protein as the energy source to survive from starvation. This result is in agreement with the findings on the effects of starvation on the body composition of juvenile African catfish by Zamal and Ollevier (1995). The mineral composition of fish is the concentration of the microelement, iron, analyzed for the fish samples, are significantly different at $p > 0.05$ across the treatments. Iron is an essential component of the respiratory pigments, haemoglobin, myoglobin and various enzyme systems. It is an essential component of various enzyme systems. As a component of the respiratory pigments and enzymes concerned in tissue oxidation, it is essential for oxygen and electron transport within the body. The iron content of the fish samples are within the World Health Organization Standard (Adewoye *et al.*, 2003). Calcium in the mineral composition analysis is also significantly different at $p > 0.05$ across the treatments.. *Clarias gariepinus* juveniles recorded a relatively higher level of calcium. Sodium, potassium and copper all have no significant difference at $p < 0.05$ across the treatments of which the composition of the elements in the fish sample was more in sodium and no concentration of copper recorded.

The growth performance and nutrient utilization of *Clarias gariepinus* fed experiment diets is presented in Table 3. There was significant difference in the mean initial Weight (MIW), mean final weight (MFW), mean weight gain (MWG), SGR, PER and FCR. There was no significant difference ($P < 0.05$) T_1 , T_2 and T_4 of MIW across the treatments. These mean values observed were significantly different as indicated in the result. Low level of feather inclusion in diets for juveniles of African catfish is practicable with substitution level of not more than 25% of the total fish meal protein, to avoid impaired palatability and reduced digestibility of the formulated diets as supported in the findings of (Serwata and Davies 2001). The growth performances and feed utilization of African catfish juveniles were negatively affected by the increased level of feather meal in the diets. Similar results were observed by Serwata and Davies, (2001) in larger size of African catfish fingerlings with initial weight of 17.1g. Such outcome appeared to be related to the reduced palatability of diets as result of high inclusion levels of feather meal which reflected by low feed intake, especially on the 75% and 100% feather meal diets. According to Yu (2008), he recommended that the inclusion feather meal to the diet of the *Clarias gariepinus* should be less than 40%, excluding the diets of some known herbivorous fish species such as tilapia and trout.

The water parameters examined are pH, D.O (MG/L), Temperature and Conductivity (m/s) their results are presented in table 4. The results revealed that pH for treatment 1 and 2 mean value is significantly different from the pH observed in treatments 3, 4 and 5. The results also showed that the highest pH was observed in treatment 4 and are significantly not different from the pH in treatment 3. Dissolved oxygen, Temperature and Electrical conductivity mean values for treatments 1, 2, 3, 4 and 5 are not significant difference ($p > 0.05$). During the experiment pH ranged from 6.0 to 7.0, Conductivity 300 to 500 m/s, Temperature 22 to 29°C while Dissolved oxygen measured 5.0 to 6.0 mg/L. These values are within the recommended range for African catfish culture (Soto-Zarazúa *et al.*, 2010).

There was no significant difference ($p < 0.05$) in the net profit value and estimated investment cost. The cost benefit ratio was higher T_2 (216.64) compared to the control diet and other treatments in the experiment as shown in Table 5. The cost benefit analysis showed that there was no significant difference in the net profit value (-24300.0 ± 0.01) and estimated investment cost (2580.0 ± 0.01).

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Table 1: Proximate Analysis of Control diet and Experimental Diet

Parameter (%)	Treatments				
	0%FTM (control)	25%FTM	50%FTM	75%FTM	100%FTM
CP	41.5	45.9	50.3	53.3	38.06

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Ash	13.5	11.0	9.5	8.3	11.0
Fibre	3.2	5.1	6.8	12.2	2.2
Lipids	11.5	12.4	7.5	7.0	12.8
Moisture	3.5	4.0	4.0	4.0	3.0
NFE	26.8	21.6	21.9	15.2	32.94
DM	96.5	96	96	96	97

CP = Crude Protein, NFE = Nitrogen Free Extract, DM = Dry Matter

Table 2: Minerals Content of Experimental Fish *Clarias gariepinus* (mg/kg)

Parameter	T1	T2	T3	T4	T5	Mean	SD	CV%
Calcium	27.40±0.10 ^b	23.17±1.02 ^b	31.41±2.05 ^a	25.0±1.03 ^b	29.11±1.01 ^a	27.16	3.17	11.68
Sodium	35.71±0.12 ^a	36.32±3.02 ^a	37.06±2.04 ^a	30.33±2.01 ^a	32.49±1.02 ^a	34.38	2.86	8.31
Potassium	12.35±1.20 ^a	13.29±2.01 ^a	16.23±0.21 ^a	11.44±1.21 ^a	11.97±0.12 ^a	13.056	1.899	14.54
Copper	0.00±0.000 ^a	0.00±0.000 ^a	0.00±0.000 ^a	0.01±0.01 ^a	0.00±0.000 ^a	0.00	0.00	0.00
Iron	0.20±0.01 ^b	0.13±0.01 ^c	0.77±0.01 ^a	0.22±0.01 ^b	0.19±0.01 ^b	0.302	0.264	87.34

Means of data on the same row with the same superscript are not significantly different (p>0.05)

Table 4: Mean Growth and nutrient utilization during the experiment for 12 weeks

Parameter	Control (0%)	Treatment 2	Treatment 3	Treatment 4	Treatment 5
MIW	13.710±2.246 ^c	22.202±2.898 ^a	20.041±1.556 ^{ab}	19.772±1.409 ^b	16.825±1.301 ^b ^c
MFW	16.160±13.122 ^a	17.380±14.930 ^a	13.880±8.270 ^b	13.260±12.260 ^b	14.930±11.880 ^{ab}
MWG	136.000±0.200 ^a	102.000±27.275 ^b	84.000±1.275 ^c	82.670±2.075 ^c	63.670±0.215 ^c
SGR	11.618±1.293 ^b	14.715±0.438 ^a	13.212±0.819 ^a	13.460±0.906 ^a	12.271±1.358 ^b
PER	13.271±1.358 ^b	15.715±0.438 ^a	14.212±0.819 ^a	14.488±0.880 ^a	12.618±1.293 ^b
FCR	3.270±2.102 ^a	1.370±2.670 ^b	1.650±1.550 ^b	1.550±1.650 ^b	2.670±1.370 ^b
CF	10.140±1.878 ^c	15.329±7.657 ^a	15.466±1.460 ^a	16.686±1.640 ^a	12.646±1.860 ^b
GIW	0.050±0.001 ^c	0.050±0.021 ^a	0.050±0.013 ^b	0.050±0.017 ^b	0.050±0.012 ^b

Means of data on the same row with the same superscript are not significantly different (p>0.05)

Table 4: Mean Water Quality Parameters during the experiment for 12 weeks

Parameter	Treatments
pH	6.480±0.129 ^b 6.872±0.094 ^a 6.755±0.082 ^{ab} 6.795±0.230 ^{ab} 6.552±0.141 ^b
DO (Mg/L ⁻¹)	5.487±0.250 ^a 5.185±0.126 ^b 4.940±0.230 ^c 4.867±0.171 ^c 5.021±0.046 ^b
Temperature	24.888±1.875 ^c 26.721±1.488 ^b 27.135±0.753 ^b 28.567±0.820 ^{ab} 29.521±4.023 ^a
Conductivity(m/s)	321.021±25.908 ^c 384.295±57.817 ^a 362.525±75.346 ^b 344.764±46.937 ^b 335.338±20.642 ^c

Means of data on the same row with the same superscript are not significantly different (p>0.05)

Table 5: Economic analysis during the experiment for 12 weeks

Parameters	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)
Estimated investment cost (Naira)	2580.0±0.01 ^a	2580.0±0.01 ^a	2580.0±0.01 ^a	2580.0±0.01 ^a	2580.0±0.01 ^a
Net Profit value (Naira)	24300.0±0.01 ^a	24300.0±0.01 ^a	24300.0±0.01 ^a	24300.0±0.01 ^a	24300.0±0.01 ^a
Cost Benefit Ratio	10.14±0.01 ^c	216.64±0.01 ^a	165.46±0.01 ^b	166.86±0.01 ^b	135.29±0.01 ^{bc}

Means of data on the same row with the same superscript are not significantly different (p>0.05)

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GROWTH PERFORMANCE AND NUTRIENT UTILIZATION OF *Clarias gariepinus* FINGERLINGS FED WITH VARIOUS PROCESSED ROSELLE SEEDS (*Hibiscus sabdariffa*) MEAL DIETS

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ABSTRACT

The effects of diet with different processed and raw Roselle seeds meal inclusion on the growth and nutrient utilization of *Clarias gariepinus* fingerlings was evaluated. Four experimental diets were formulated using raw roselle seeds (RRS), fermented roselle seeds (FRS), Boiled roselle seeds (BRS) and control (CTR, contraining no roselle seeds) to feed *Clarias gariepinus* inside twelve plastic aquaria. One hundred and eight fingerlings of *Clarias gariepinus* average weight of 12.67 ± 0.91 g were randomly distributed into the tanks at the rate of 15 fish per tank with three replicate per treatment. The fish were fed twice daily at 5% of their biomass twice daily for 84 days. At the end of the experiment, proximate composition and growth parameters were analysed. Data obtained was subjected to analysis of variance at α 0.05. Result showed that growth performance and feed utilization indices were lowest for fish fed Raw Roselle Seed diet and highest for Fermented Roselle Seeds. There were significant differences ($p < 0.05$) in the processing methods with the fish fed FRS having the highest weight gain (4.37 ± 0.61), specific growth rate (0.22 ± 0.04), protein efficiency ratio (2.54 ± 0.37) and protein intake (1.73 ± 0.04). From the obtained results, fermented roselle seeds could be become an excellent economic and valuable source of the nutritional factors which can be used in fish feed.

Key words: Roselle, Fermented, Boiled, *Clarias gariepinus*

INTRODUCTION

Biochemical components of plant protein sources is a problem which has been researched on and found to limit their utilization as potential alternative in fish diets and this has drawn much attention considering the fast growth of the fish farming industry (Tacon, and Metian, 2008) Processing of feedstuff diets for fish are therefore essential to enhance the utilization of plant protein in fish production (Tacon *et. al.* 2009).

Roselle seeds contain about 35.90% crude protein (CP), 10.14% ether extract (EE), 10.09% ash and 15-17% crude fibre (CF) (Dashak and Nwanegbo,2002) which makes it a suitable alternative plant protein source for fish feed. The unprocessed Roelle seed has been reported to also contain total phenols, tannin and phytic acid as common anti-nutrients and these have been shown to have detrimental effects on the health and performance of animals (Dairo *et. al.* 2011).

In this study, the dietary effects of inclusion of raw and differently processed Roselle seeds were investigated on the growth responses, nutritional indices of *Clarias gariepinus* fingerlings.

MATERIALS AND METHODS

Experimental site

The research was conducted at the Research farm of the Department of Fisheries and Aquaculture, Federal University Dutsin-ma, Katsina State for a period of 12 weeks.

Source of fish used

A total of One hundred and eighty *Clarias gariepinus* fingerlings were obtained from a reputable fish farm in Katsina were used for the experiment. Fifteen fish were randomly selected and distributed into 12 the tank containing 30 litres of de-chlorinated water and allowed to acclimatize for one week before the commencement of the experiment.

Processing methods of Roselle seeds

Roselle seeds (*Hibiscus sabdariffa*) was procured from the local market in Dutsinma, Katsina State, Nigeria. The collected seeds were cleaned by winnowing and hand picking of stones and debris. The raw Roselle seeds were subjected to two processing methods:

Raw

16kg of the seeds was sorted to remove stones and debris and thoroughly washed, sun dried and millied for inclusion in the experimental diet.

Boiling

16kg of the seeds was added to 40 litres of already boiling water over fuel wood and cooked for 30 minutes, a method described by Kwari *et al.* (2010). The water was drained and the seeds were sun-dried until crisp.

Fermentation

16kg Roselle seeds was soaked in 20 litres of water for 8 hours. The soaked seeds were then drained and placed in an air tight polythene bag and allowed to ferment for 96 hours. After which the seeds was spread on a tarpaulin sheet, sun-dried until crisp and crushed in a hammer mill as described by Anbgulu *et al.* 2019.

All the seeds were crushed separately in a hammer mill to the required particle size and incorporated into the experimental diets.

Procurement and Processing of Test Ingredients.

Feed ingredients were purchased from the local Market located in Dutsin-ma. These ingredients include: yellow maize, soybean meal, Roselle seeds, Wheat bran, salt, binder, palm oil. Other ingredient such vitamin/premix and bone meal were purchased from an agro-allied shop located at Katsina.

Feed ingredients were milled separately, mixed to form a dough using the local starch as a binder. The dough was pelleted using a 2mm diameter die. The pelleted fish feeds were sun dried properly in order to prevent fungal growth and then stored in an air tight container.

Four diets were formulated designated as Diet RRS (Raw Roselle Seed), BRS (Boiled Roselle Seed), and FRS (Fermented Roselle Seed) with CTR as the control containing no Roselle seed.

Feed formulation and feeding Trials

All the treatments were in triplicates. Before the commencement of the experiment the fish were starve 24rs prior to the onset of the experiment to empty their gut and increase their appetite and reception of the new diet. Feeding was done twice daily (7.00 and 16.00) at 5% body weight per day with necessary adjustment made in accordance with their body weight change. All fish were weighed per treatment and this was done bi-weekly.

Results and Discussion

Table 1 shows the ingredients composition as well as the result of the proximate analysis of experimental diet incorporated with different processed Roselle seeds. The proximate analysis shows that the feed having the highest (25.24 %) value of the crude protein was in the diet containing fermented Roselle seeds followed by the feed containing the no Roselle seeds, that is the control (23.93%) and the least value from that containing the raw Roselle seeds (22.33%).

From the results of this study, the differently processed Roselle diets (FRS, BRS and CTL) showed improved performance in the specific growth rate (SGR), food conversion ratio (FCR) and protein efficiency ratio (PER) of the *C. gariepinus* fingerlings as compared to the raw diet (RRS) suggesting an improvement in the nutritive values of the processed seeds which encouraged better utilization of the Roselle diets. Detoxification and reduction on the quality and quantity of ANF in the raw seeds by various treatments has been reported by Siddhuraju, and Becker, 2003 to the improvement in the nutritive value of the processed seeds.

The result for the growth performance and nutrient utilization is showed in Table 2. The results revealed that *C. gariepinus* fed fermented Roselle seed meal were superior to the fish fed raw and the boiling method. The fish fed the fermented Roselle seed had a mean weight gain of 4.37 ± 0.61 g, which was significantly higher ($p < 0.05$) than the fish fed with boiled Roselle and fed with the control having values of 2.57 ± 0.77 g and 2.57 ± 0.16 g respectively and lastly the raw Roselle 1.36 ± 0.39 g. This might be due to the fermentation process which is recognized as converter of food compound into structurally related but financially more viable food through the activities of microbial cells. The result recorded is supported by various reports by Ari and Ayanwale (2012) on the effect of different fermentation methods on the health and growth responses of mono gastric animals. The synergistic effect of host micro-organisms and beneficial fermentation microbes must have led to reduction in the content of pathogenic bacteria and increased the population of useful micro flora in the gut, resulting to improvement in the gastro-intestinal health and performance of monogastrics. Ari *et. al*, 2012 reported that another positive effects of fermentation could have originated from enzymes of the seed itself. The poor growth recorded in the fish fed with the diet containing raw Roselle seeds could be caused by poor palatability or presence of endogenous anti-nutrients in the unprocessed Roselle seeds. Anti-nutrients reduce lysine bioavailability and cause depressed appetite and loss of body weight.

Specific growth rate with highest value of 4.58 ± 0.18 was recorded in fish fed RRS and lowest value of 1.64 ± 0.27 was recorded in fish fed FRS. The non- significant differences between fish fed diet RRS, FRS and CTL indicates that the fish were able to digest the diets and convert the diet into body tissues with the same degree of efficiency.

Protein efficiency ratio was highest in diet FRS (2.54 ± 0.37) indicating better utilization of protein for growth in fingerlings fed the diet.

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High mortality was recorded in the fish fed diets containing raw (unprocessed) Roselle seeds, this could be attributed to the presence of anti-nutrients such as tannins and phytic acids which when in high amount has an adverse effect on the gastro intestinal tract (GIT) of fish (Fagbenro, *et. al*, 2005).

Table 1: Composition of Experimental Diets

Ingredients	Treatment			
	CTR	RRS	FRS	BRS
Yellow maize	8.97	2.22	2.22	2.22
Wheat bran	8.97	2.22	2.22	2.22
Fishmeal	37.09	29.22	29.22	29.22
Soybean meal	37.09	29.22	29.22	29.22
Roselle seed	00	29.22	29.22	29.22
Cassava starch	2.0	2.0	2.0	2.0
Bone meal	3.0	3.0	3.0	3.0
Premix	0.25	0.25	0.25	0.25
Methionine	0.20	0.20	0.20	0.20
Palm oil	1.75	1.75	1.75	1.75
Salt	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20
Total	100	100	100	100
Proximate Composition (%DM)				
Moisture	3.61	2.36	2.06	3.69
Crude Protein	23.93	22.33	25.24	22.51
Ash	14.69	9.19	15.58	12.13
Ether Extract	3.89	3.15	4.26	3.04

Table 2: Growth performance and nutrients utilization of *Clarias gariepinus*

	FRS	BRS	RRS	CTR
Final weight	17.63±0.41 ^a	15.23±0.40 ^b	13.22±0.10 ^c	16.40±0.47 ^{ab}
Weight gained	4.37±0.61 ^a	2.57±0.77 ^{ab}	1.36±0.39 ^b	2.57±0.16 ^{ab}
%weight gained	33.50±5.91 ^a	21.29±7.31 ^a	11.65±3.69 ^a	18.59±1.28 ^a
Specific growth rate	0.22±0.04 ^a	0.19±0.02 ^a	0.06±0.01 ^b	0.14±0.01 ^{ab}
Feed conversion ratio	1.64±0.27 ^a	3.06±1.29 ^a	4.58±0.18 ^a	2.57±0.15 ^a
Protein intake	1.73±0.04 ^a	1.32±0.09 ^a	1.18±0.02 ^a	1.57±0.33 ^a
Protein efficiency ratio	2.54±0.37 ^a	2.00±0.67 ^b	1.15±0.34 ^a	1.64±0.09 ^a
Survival rate	93.33±3.33 ^a	83.33±3.33 ^a	43.33±6.66 ^b	100.00±0.00 ^a

Values are given in mean ± standard deviation. Values in the same row having the same superscript letters are not significantly different from each other. (P<0.05).

Conclusion

The evaluation of the effect of raw and differently processed *M. pruriens* seed diet on growth parameters, digestibility and haematological examination of *C. carpio* fingerlings indicated that inclusion of the raw mucuna diet caused poor growth performances and reduced food utilization.

Conclusion

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CONCLUSION

The evaluation of the effect of raw and differently processed Roselle seed diet on growth parameters and nutrient utilization of *C. gariepinus* fingerlings indicated that inclusion of the raw Roselle seed diet caused poor growth performances and reduced food utilization. Fish fed with diet containing fermented roselle seeds gave the best growth performance as well as the nutritional utilization. Accordingly, fermented roselle seeds could be used as a supplement food or as a diet enrichment especially in the low protein diets.

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AN APPRAISAL OF AQUACULTURE VALUE CHAIN ACTIVITIES IN KAINJI LAKE BASIN, NIGERIA

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ABSTRACT

The study is a review of aquaculture value chain activities in Kainji Lake Basin with reference to New Bussa and surrounding communities which is the epicenter of the activities. Secondary data of published literatures and observations were used for the review. Value chain activities in aquaculture are worth over 50 billion naira in the lake basin creating jobs and wealth for men, women and youths. Table size fish culture is the prime enterprise activity driving fish feed, fingerlings, processing and marketing. Interestingly, most aquaculture actors earn multiple incomes from engaging in multiple value chain activities. Motivating factors are entrepreneurship drive, access and availability of technologies, regular supply of electricity, availability of feed inputs, communication networks particularly mobile phones, distant fish buyers, group association to tackle market price and prompt payment, access to fisheries experts for advisory and consultation, enterprise creativity, experience capitalization with multiple income and relative low cost of production. There is need to step up promotion of aquaculture entrepreneurship through value chain concept for actors to derive more economic benefit and managerial competencies in rural agribusiness.

Keywords: aquaculture, value chain, enterprises, Nigeria.

Introduction

Value chain (VC) is a global strategy and framework in development intervention used to understand and harness potential of actors in the commodity process. By definition, “value chain is the full range of activities which are required to bring a product or service from conception, through the different phases of production, delivery to final consumers, and final disposal after use” (Kaplinsky and Morris, 2001). Value chain development has become an important component of programs in agricultural and rural development that aim to create job, reduce poverty and food insecurity.

As a result, value chain analysis (VCA) approach has been integrated into fisheries and aquaculture sectors research and intervention programmes for better outcomes and impacts by organization like WorldFish Center, Fisheries Society of Nigeria (FISON), National Institute for Freshwater Fisheries Research (NIFFR) as noted by Adeleke *et al* (2015) and Kruijssen *et al*, (2016). Over a decade, NIFFR has keyed into the fisheries value chain concept in its research and intervention projects in delivery of national mandates and collaboration with international partners such as CORAF/WECARD, FAO, DFID, and WorldFish Center among others. NIFFR in 2015 carried out aquaculture value chain survey of Kainji Lake Basin (Sule *et al* 2021). Also, in 2012, NIFFR carried out aquaculture value chain mapping of North East and West to document status, strength, weakness, threats and opportunities in production, postharvest, ancillary components for intervention (Omojowo *et al*, 2015). Also, under West Africa Agricultural Productivity Programme (WAAPP) project between 2012-2015 which was a sub-regional project, the concept of VC was used to implement aquaculture research outcomes in 20 adopted villages and 4 agricultural research outreach Centers (AROCs) within 20 kilometers radius for youths, women and men which transformed the communities particularly Monai into “Fish Farming Villages”. Remarkable impact is that New Bussa and surrounding communities under Borgu local government is recognized as aquaculture

hob in Niger State (Ifejika *et al*, 2021; Ebiloma *et al* 2018). Impact is on booming multibillion aquaculture enterprises estimate at over ₦50billion naira value chain activities on production of table size fish, fingerlings, pelletized feed production, processing, fingerlings, fish marketing, inputs supply, fish oil, transportation services and other itineraries services, thus, contributing to nutrition and food security, jobs and wealth creation for men, youths and women. Interestingly, most aquaculture actors earn multiple incomes from engaging in multiple value chain activities such as fingerlings-table size-feed production, fish processing-marketing, fingerlings-table size-feed production-consultancy service, feed-table size production, input sales-table size, transportation-table size, fingerlings-table size-processing-marketing, processing-marketing.

Methodology

This is a review paper on the subject matter of value chain in aquaculture in Kainji lake basin, Nigeria. The review specifically was targeted at activities in New Bussa and surrounding communities which is the center of aquaculture in Borgu local government area under Niger state. Secondary published literature was used for the appraisal on aquaculture activities on the lake basin.

Results and Discussions

On table size production with over 1500 fish farmers engaged in table size fish culture enterprise mostly catfish species which is found to be profitable whereas small proportion engage in tilapia and heterotis species in the area. The multibillion table size aquapreneurship activities is the driving force for fingerlings, feed, processing and inputs supplies which is dominated by men (65-75%), youths (10-15%) and women (less than 10%). Progressive and large scale fish farmers practice intensive system, monoculture, flow-through, earthen ponds followed by use of concrete, tarpaulin, and plastic ponds. An insight into economic value of fresh table size fish production was provided in 2019 investigation of 12 middlemen showed that an estimated 7,680 tons of live catfish worth ₦11,255,520,000.00 were sold from Kainji Basin at the market rate ₦655/kg. Active clusters of fish farms existing in New Bussa are Senior camp, Agric area, FGC, and surrounding communities Monai, Koro, Faku and New Awuru, and Yauna. Current price for fresh cultured table size has rose from ₦668 in 2019, ₦785 in 2020 and ₦1200.00 in 2022. Net return on investment was found to be between 30% and 45% within 5 to 8 months culture period of table size catfish. Presently, catfish fingerlings production from local hatchery producers is insufficient to meet demand of table size production in quantity. Local hatchery operators are less than 20 with two government hatcheries using water re-circulatory system, wooden vat, and concrete tanks whereas fingerlings are transported in 50liters jerry can. Observed gap in local fingerlings production is put at over 100million fingerlings in a year worth more than ₦1billion. Currently, fingerlings are sourced and suppliers from south western states of Lagos, Oyo, Ekiti, Kwara, and Ogun. Men and youths own and operate most of the hatchery even though few women folks have knowledge of breeding technique and breed in government hatcheries.

Commercial pelletized farm-made fish feed enterprise activity is dominated by men as owners and workers compared to women. Dry pelletizer machine is commonly used over hammer machine to produce 2-9mm feed sizes from local feed inputs (maize, soya bean, clupeid, wheat offal, cassava peel, millet, groundnut cake), which is sun dried. Over 85% of the fish feed producers are located in New Bussa with few in Monai and Faku communities which has risen from 19 in 2017 to 20 in 2022 due to high demand in fish feed, new entrants to fish farming and profitability of enterprise (Ifejika *et al*, 2021). Current average price for pelletizing 1kg of feed rose to ₦500 in 2022 against ₦288 in 2017 indicating 42.4% change in price, while annual estimated fish feed production is about one metric tonne for table size fish farmer in the environ and other states. Gender role in pelletized fish feed activities is skewed against women due to muscular requirement for men and youths to perform most task on grinding, packing, and spreading (Omeje *et al*, 2021). Despite technology availability for production of extruded fish feed (0.3-1.5mm; 2-9mm), all extruded feed are supplied from outside which is imported or produced in Nigeria by feed companies. Extruded fish feed sales activities is gender balance as men, women and youths engage in it. Between 2017 and 2022, extruded catfish feed brands marketed in the area has dropped from 8 to 6 namely Skretting, Coppens, Aller

Aqua, Ecofloat, Blue Crown, Aqualis, whereas Vital feed*, and Top Feed* are not available now. Also, there has been price change from between ₦9,200.00- ₦12,500.00 to ₦13,000.00- ₦18,000.00 for crumble and 2mm-9mm. Extruded fish feed price change for crumbles was (47.6%), 2mm (49.22%), and 3mm (47.58%). Skyrocketed high cost of feed inputs by more than 50% is a threat to profitable and sustainable aquaculture enterprise due to high tax and inflation in the economy since 2020 and worsened in 2022. Table size fish farmers use extruded feeds of 0.3-3mm to feed fingerlings for the first 8-11 weeks then divert to pelletize farm made fish feed to reduce operating cost of feed and make more profit.

Multibillion lucrative fish processing value chain activity in aquaculture is driven by few large scale fish processors mostly men compared to women who are more at small scale level in the area. Fish processors transport a truck load of packaged smoked fish in cartons (550-650) weekly to Onitsha market in Anambra state, but sometimes two during festive periods (Christmas and Easter). Other destinations supplied with smoke fish at small quantity are Lagos, Abuja, Ilorin, Minna, Kano and Kaduna. Women gender mostly carry out fish gutting, washing, smoking, and packaging while men and youths convey fresh pond harvested fish, packing, firewood and smoking. Economic value of smoked catfish is worth over two billion in a year. Recent study reported by Olaosebikan (2021) showed that nine (9) fish processors between July 2019 and February 2020, smoked a total of 32,340 cartons of processed smoked fish worth ₦1,746,360,000.00 billion transported to Onitsha from New Bussa. Note that 3kg of fresh catfish gives you 1kg of smoked fish with loss of 70% body weight. In the lake basin, fish processors have insisted in the use of improve banda, unhygienic environment and packing with dry grass in cartons and had resisted adoption of galvanized smoking kiln which is climate smart, economical, safe food standard free of carcinogenic aromatic hydrocarbons in compliance with export market to Europe and USA. Adoption of fish smoking kiln is high among fish processors in urban towns than rural communities, thus enabling processors to package, export and earn foreign exchange as well as drive table size and fingerlings activities. Also, sensory evaluation result showed that electric kiln followed by gas and charcoal has the best fish product appearance, colour, texture, taste and flavor. Value addition practices is on the use of catfish to prepare pepper soup in beer parlours costing ₦500.00 per plate and making of fish barbecue with spices and Irish potatoes costing around ₦1200.00 to ₦2000.00 depending on size. Fish oil is by a product from fish during smoking which gives income to processor and is in high demand due to its medicinal and health benefits.

Culture catfish fish marketing is another lucrative value chain activity that women folks dominate at small scale compared to men and youths with high return on investment. Actors engage in fresh and smoke fish marketing within the environment and long distance urban markets like Onitsha in Anambra State for smoked fish and Abuja for fresh fish as the primary target whereas other locations are Minna, Ilorin, Kaduna, Kano, Zaria, Lagos, Ibadan, Jos. A recent study by Umar (2020) cited by Olaosebikan (2021) showed that between July 2019 and February 2020, 32,340 cartons of dried fish worth an estimated ₦1,746,360,000.00 were transported to Onitsha from New Bussa. Also, in 2019, investigation of 12 middlemen showed that an estimated 7,680 tons of live catfish worth ₦11,255,520,000 were sold from Kainji Basin at the market rate ₦655/kg. Now in 2022, the value of fresh and smoke catfish have almost doubled with rise in price of catfish per kilogram from ₦655 to ₦1200 for fresh and smoked is between ₦3000 to ₦4500 for per/kg. Men are major buyers as middlemen from far and near places while women and youth buy in smaller quantities due to large capital requirement. Marketing strategies is still face to face by over 80% and 20% online through mobile phone voice calls, voice message, short message sending, and pictures as well as social media on WhatsApp and Facebook to show fish size and bargain price. However, it is established fact that distant fish buyers price better, pay higher price and promptly than local buyers which agrees with findings in Oyo, Niger, Delta and Anambra States by Ifejika, (2015).

Other itineraries on secondary value chain activities that is generating job and income are pond construction by youths, fish transportation by youths and young men, input sales on feeds and equipments, consultancy services on training, supplies and advisory services, financial services for capital by banks used by less than 20%, online quick money lenders with high interest, fish harvest/cropping by youths and equipment hiring like dragging net, and pumping machine. Indirectly involved the value chain activities are crop farmers producing soya bean, maize, millets and fishers supplying clupeids for fish feed ingredients.

Motivating factors for the success of the activities are entrepreneurship drive, access and availability of technologies, regular supply of electricity, availability of feed inputs, communication nets particularly mobile phones, distant fish buyers, group association to tackle market price and prompt payment, access to fisheries experts for advisory and consultation, enterprise creativity with multiple incomes, experience capitalization on reuse of pond waste water, and relative low cost of production. Some challenges are poor access to quick loan from financial institutions, flooding, low market price for fresh fish, adjustment of meter by fish buyers/marketers and commercial processors to cheat producers and processors, high cost of feed inputs, inflation due to unstable price, pilfering of fish in the pond, insufficient fingerlings production to meet demand, resistance to adopt fish smoking kiln, fish diseases, water quality issue on fingerlings production, lack of interest to take agricultural insurance against risk, unstable group association, insecurity due to bandits and lack of some working tools. Ifejika *et al* (2021) highlighted some of the success factors on fish feed enterprise in New Bussa and surrounding communities.

CONCLUSION AND RECOMMENDATION

From the review, aquaculture enterprise is thriving in the value chain activities, but not yet optimal to harness the economic opportunities. There is need to promote the multibillion aquaculture enterprises in the lake basin through value chain concept for actors to derive more economic benefit through managerial competencies in business. Emphasis should focus on building capacity to adopt new business orientation, modernization of activities on fish packaging, process fish in compliance to food safety, distance and super market leveraging on social media tools and networking as well as investment on hatchery to reduce over dependency on buying for south western states.

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Evaluation of growth performance of *Clarias gariepinus* in Cage aquaculture as additional income to artisanal Fishermen in Hadejia Jama'are Komadugu Yobe River basin, Nigeria.

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ABSTRACT

This study examined the growth performance of *Clarias gariepinus* in fixed type cage in Hadejia Jama'are Komadugu river basin. The fingerlings (16.7 ± 0.15 g to 16.8 ± 0.25) were stocked at 25 fish/m³ /cages and fed with commercial diet 42% crude protein twice daily for period of 148 days. At the end of rearing period, the results revealed that, *Clarias gariepinus* cultured in station B gave the highest growth performance in terms of mean weight gain 1337.60 ± 10.45 g/fish and differs significantly among the stations. The Specific growth rate 3.20 ± 0.0 %/day and FCR 1.34 were higher in station A and station C respectively. The Condition factor value did not differ significantly among at ($p > 0.05$) Better K value 1.23 ± 0.0 was obtained in station A compared to 1.34 ± 0.0 in stations C. The Best survival rate of 86% was obtained in station C, compared to 74% in station B. Statistically, the results showed significant difference at ($p < 0.05$) among the stations. Water quality parameter such as temperature, BOD and nitrate in all stations showed no significance differences at ($p < 0.05$). While pH, turbidity, DO and nitrate values differs significantly at ($p < 0.05$). The result also did not differ in investment cost (ICA) among the stations. However, the result differs significance in-net production value (NPV), gross profit (GP) and profit index (PI) respectively among the stations. The NPV is better in station B, compare to stations B and C respectively. Therefore, better NPV and profit index found in this study shows that, cage culture practices is economically viable in the basin, fishermen can be encouraged to practice so as to serve as additional source of income to fishers in Hadejia Jama'are Komadugu Yobe river basin in Northern Nigeria during the low catch or restricted period.

Key: cage, *Clarias*, income and river basins

Introduction

Hadejia jama'are Komadugu Yobe is one the tropical floodplain wetland that are characterized by a multi species stock of fish. Without doubt fishing and aquaculture remains important part of the economy of the basin by both men and women. It has been reported that between 40-70 of the rural house household are engaged in fisheries in different occupation at different time of the year (Ladu *et al.*, 2013; Adams and Hollis 1978; Neiland *et al.*, 1997). However, unsustainable fishing practices and other factors such as habitat destruction, pollution, climate change or invasive species have led to fish stock depletion and collapse. During low fish catch and closed season majority of the permanent fishermen find it difficult to have a means of livelihood. Cage fish farming is one of the production systems that have been identified to have the potential to contribute to increase fish productivity. Today, cage culture is receiving more attention by both researchers and commercial producers. According to Abdullahi (2020). Cage culture is relatively new in north central and North-East Nigeria compared to southern Nigeria where it has been practiced over the years Therefore, creating alternative income generating activities for the fishers themselves or their families diversifies their livelihoods, and may to some extent mitigate adverse impacts caused by restrictions on access to fishing Wiriy *et al.* (2013) concluded that Cage culture globally is hugely varied, ranging from subsistence level holding of a few kilos of fish in small nets to salmon farms producing more than 5 000 tonnes per year. This makes cage culture one of the most flexible form of aquaculture. The productive vast water bodies including dams built across the basin could be utilizes for 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. The objective of this study is to assess the potential of cage culture system in rivers as alternative source of income of the fishers depending on inland fisheries. One important way in which the seasonal impacts of closed seasons and restrictions on fishing can be mitigated is through livelihoods components that are part of work to improve fishery management (Islam, 1999).

Study site

The Hadejia Jama'are Komadugu Yobe (HJKY) River Basin is situated in the Northern part of Nigeria. It traverses between six States of Bauchi, Borno, Jigawa, Kano, Plateau and Yobe. The main rivers of the basin are the Hadejia and the Jama'are, which meet in the Hadejia-Nguru Wetlands from where they continue as the Yobe (Hospitalia Consultaire, 2017). The river basin flows into the Northern pool of the Lake Chad and contribute less than 2.5 percent of the total inflow into the Lake Chad Solomon (2016). The basin is a major economic hub for pastoralists, fishing and farming represent about 75% of the indigenous community population. The wetlands represent their entire source of livelihoods through farming and fishing activities. (Ladu *et al.* 2013; Solomon *et al.* 2016; Birdlife international, 2015).

Material and Methods

Three inches (3'PVC pipe, nets, gum, and sized materials were used in construction of low-cost fish Cage (fixed type) in three rivers in the basin (Otubusin, 2011). The size of each cage is (2x2x1.5m²) made up of frame lined with net (210/9, 12.7mm mesh size. The fish fingerlings were stocked at 25 fish/m³ fed with commercial formulated feed at initial 5% body weight per fish /cage for the first 4 weeks after which the fish were feed to satiation twice daily. The culture period lasted for 148 days. Five fish were sampled every month, total length (TL) and standard (SL) length, and individual live body weights (kg) were measured using a measuring board, and weighing balance (cm). Water quality parameters (Water temperature, pH, dissolved oxygen concentration, Turbidity, Biological Oxygen Demand (BOD) Nitrite and nitrate) were monitored and measured monthly using a multiparametric quality analyzer and laboratory analysis.

Growth Performance

Growth parameters (Weight gain, Specific growth rate, Condition factor, Survival (SR) Feed conversion ratio (FCR) and Cost-benefit analysis of the cage was calculated using standard formula from (Fasakin 2001; New 1989).

Data analysis

One-way Analysis of variance were carried out to determine significant differences in growth performance among the different stations. All results were analysed using SAS Statistical software.

Result and Discussion

Data on the growth indices, survival and condition factor is presented in Table 1. Station C had higher mean weight gain value 1337.60 ± 10.45 g/fish which differs significantly among the stations at ($p > 0.05$). The specific growth rate, Food conversion ratio and condition factor did not differ significantly from each other. Although, there is significance difference among the stations in mean weight gain. Relatively higher mean weight gain found in station C may be due to the natural food organism and nutrients loads of the rivers. However, there is appreciable increase in mean weight gain (> 1 kg) in all the stations. The better performance of fish in growth rate found in this study may be linked to factors such as, relatively high protein found in feed, abundance of natural food organism and adequate water depth maintained (Halwart *et al.*, 2017; Balogun, 2016). Beside the adequate protein contained in the diet, natural food organism was observed during the study. Natural food organism in water have been known to produce excellent growth rates in cultured fish (Ita and 1998).

The SGR ranged from 2.8 to 3.2g/d. The high SGR observed in this study could be due to impact of lower stocking density which is resulted from mortality. High value of SGR found in the study are in

agreement with finding of Omoregie *et al* (1993). The relatively better FCR of 1.3 indicates efficient food utilization of the fish feed. The condition factor (K) found in this study had values above 1. Olapade *et al* (2019) obtained a similar result. Condition factor value found in the present study is an indication that the environmental conditions was favourable for the fish and feeds were properly utilized for better growth and sound health (Madhusoondanan *et al.*, 2016).. The high survival rate recorded in all stations could be attributed good evaluation of the sites for cage culture practice including water depth, water quality, adequate and availability of food and food organism. The success of an aquaculture operation largely depends on the proper selection of the site to be developed into a farm fish (Agyakwah, *et al* 2020). The survival of *Clarias gariepinus* in this study is similar to work done by (Habib *et al.*, 2015).

The mean value of water temperature ranges between 26.8°C to 27.21°C with higher mean temperature recorded in station C and did not differ significantly from each other ($p < 0.05$). However, pH, DO, turbidity and nitrite values differ significantly from each other at ($p < 0.05$). The variation could be due to Agricultural activities around the area. Many studies have found that growth performance can be affected by water temperature, DO level and nitrite-nitrogen (Yuen *et al.*, 2019). The quality parameters (D.O., pH, temperature, and $\text{NO}_2\text{-N}$ found in this study were within the optimal limits for the growth of tropical aquaculture fish as recommended by (Boyd 1990; Mengistu *et al.*, 2020). The finding is similar to studies by (Ameworwor 2014; Habib *et al* 2015; Asmah *et al.* 2014) The growth rates recorded in the present study were not affected by the water quality.

The result of cost benefit analysis in Table 1 did not differ significantly in investment cost (ICA), incidence of cost and benefit cost ratio in all the stations. However, the result differs significance in-net production value (NPV), gross profit (GP) and profit index (PI) respectively at ($p < 0.05$) from each other. The higher NPV and profit index found in this study shows that, cage culture is economically viable. Low-cost of cage culture materials, availability of water supply and good quality feeds adopted in this study might explain the high net production value and best (PI) in all the stations.

Conclusion

It may be concluded fish cage aquaculture can be well utilized in the river basin, profitable and had lower investment cost involved. With increasing emphasis on aquaculture as an alternative to dwindling artisanal fishing couples with high cost of land and water supply, cage fish culture from the foregoing, can serve as additional source of income to fisher in the Basin.

Table 1: Growth and Feed Utilization *Clarias gariepinus* Raised under Cage Culture System.

Parameters	Stations		
	Marke (A)	Katagum (B)	Nguru (C)
Initial mean weight (g/fish)	16.70 $\pm$ 0.15 ^a	16.37 $\pm$ 0.50 ^a	16.87 $\pm$ 0.25 ^a
Final mean weight (g/fish)	1109.02 $\pm$ 4.08 ^b	1353.90 $\pm$ 10.32 ^a	1064.8 $\pm$ 32.45 ^b
Initial mean Standard length (cm)	10.59 $\pm$ 0.44 ^a	10.24 $\pm$ 0.12 ^a	10.83 $\pm$ 0.23 ^a
Final mean Standard length (cm)	45.03 $\pm$ 0.20 ^a	45.17 $\pm$ 1.48 ^a	42.97 $\pm$ 0.24 ^a
Mean weight gain (g/fish)	1093.8 $\pm$ 5.03 ^b	1337.60 $\pm$ 10.45 ^a	1048.48 $\pm$ 32.70 ^b
Specific growth rate (%/day)	3.20 $\pm$ 0.0 ^a	3.00 $\pm$ 0.0 ^a	2.80 $\pm$ 0.00 ^{aS}
Feed Intake(g)	1972.2 $\pm$ 6.04 ^a	2010.0 $\pm$ 8.84 ^a	1895.8 $\pm$ 89.37 ^a
Food Conversion Ratio	1.41 $\pm$ 0.119 ^a	1.30 $\pm$ 0.00 ^a	1.46 $\pm$ 0.02 ^a
Condition Factor (k)	1.23 $\pm$ 0.02 ^a	1.25 $\pm$ 0.07 ^a	1.34 $\pm$ 0.02 ^a
Survival (%)	82.00 $\pm$ 2.00 ^{ab}	74.00 $\pm$ 2.0 ^b	86.00 $\pm$ 2.0 ^a
Cost of feed (N)	723.15 $\pm$ 1.04 ^a	737.02 $\pm$ 1.53 ^a	695.15 $\pm$ 15.45 ^b

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Cost of fingerling (N)	45 ± 0.00 ^a	45± 0.00 ^a	45± 0.00 ^a
Cost of fish Cage (N)	6975± 0.00 ^a	6975± 0.00 ^a	6975± 0.00 ^a
Investment Cost Analysis	7639.68± 9.10 ^a	7678.46± 0.09 ^a	7683.86± 0.69 ^a
Net production value @ 950	44782.62±446.81 ^a	49480±448.09 ^b	45028.36± 158.71 ^a
Gross profit	37039.47± 445.76 ^a	41722.98± 446.57 ^b	45028.36± 158.71 ^c
PROFIT INDEX	61.93± 0.53 ^a	67.14± 0.47 ^b	64.95± 1.67 ^a
Incidence of cost	0.02± 0.00 ^a	0.015± 0.00 ^a	0.015± 0.00 ^a
Benefit cost ratio	5.78± 0.06 ^a	6.38± 0.06 ^b	5.84± 0.03 ^a

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GROWTH AND SURVIVAL RESPONSES OF *CLARIAS GARIEPINUS* LARVAE FED DIFFERENT STARTER FEEDS

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ABSTRACT

The availability of starter feed for rearing of *Clarias gariepinus* larvae is of enormous importance. Knowledge on other starter feeds which can be used or substituted with the known feeds will promote breeding of catfish, increase growth, increase survival and reduce cost. The aim of the study was to determine the growth parameters and survival of *C. gariepinus* larvae fed different starter feeds. The starter feeds were for D₁ Artemia which represent control, D₂ Egg yolk only, D₃ 0.3mm Coppens only, D₄ Coppens and Egg yolk and D₅ Artemia and egg yolk. The results revealed that the combination of Coppens and egg yolk has the best in weight (6.4g), length (8.2cm) and survival (96%), followed by Coppens weight 5.1g, length 6.9cm and survival 88% while the least was in Artemia 1.2g, 3.2cm and 58% and egg yolk 1.3g, 2.5cm and 50%. The research showed that combining of 0.3mm Coppens with egg yolk increased the growth in the hatchlings of *C. gariepinus* or the use of Coppens alone can substitute for Artemia which gave poor result.

Keywords: African mud Catfish, Breeding, Artemia, Coppens and Egg yolk

Introduction

Fish breeding is an essential aspect of aquaculture for propagation and sustainability of aquatic animals including fish. It enables fingerlings availability yearly, in turn populate fish for use by the growing population. However, in as much as breeding and fish sustainability is concerned there is a need for quality, available and low cost feed for the larvae (Ochokwu *et al.*, 2015). With the rise in the cost of materials, there is an enormous rise in the cost of the starter feeds. The major used feeds like Artemia is less available, not effective and expensive (Nwachi and Irabor, 2015). Meanwhile, larval stage of African mud catfish is fragile and require careful management for their survival. The shifts from endogenous to exogenous feed is a crucial moment in a life of fish larvae (Adewumi, 2015). Mortality can be high as larvae wean from yolk absorption and ready to be fed with exogenous feed if the feed given is adulterated, infected with fungi, low quality, and have a low nutrients value. The major problem in fish breeding and raising the fry to fingerlings is in number of fertilized eggs, percentage hatchability, the quality of the compounded feed given to the hatchlings, the management practices involved during the transition stage from larvae to fingerlings (Adewumi, 2015). Other factors are water quality parameters of the water used. Researchers have used other exogenous feed to ascertain the growth and survival of the hatchlings. Faruk *et al.* (2019) used Artemia, Skretting and combination of Artemia and Skretting, Mollah and Hossain (1997) utilized Tubificid worm, boiled egg yolk, Sabinco shrimp, and compounded feed, Aruho *et al.* (2017) used combination of de-capsulated Artemia and dry feed, Moina and dry feed, and dry feed only, while Musa *et al.* (2012) used Artemia, Fish meal and Maize bran. In this research five exogenous feeds were utilized such as Artemia control, Egg yolk, Coppens, Coppens and egg yolk and Artemia and egg yolk which have not been used previously. The aim of the research is to ascertain the growth and survival of *C. gariepinus* hatchlings fed different starter feeds.

Materials and methods

The study was carried out in the wet laboratory, Department of Fisheries, Modibbo Adama University, Yola for 33days from 11thFebruary to March 19th, 2022.

Experimental fish of *C. gariepinus* parent average weight 1000g were used for the breeding process according to (Onyia *et al.*, 2020). Assessment of the starter feed on the growth and survival of the hatchlings were performed in 120L plastic bowls containing 80L of water. 750 larvae with each bowls containing 50 larvae in three replicates were fed with D₁ control Artemia feed powder, D₂ Egg yolk, D₃ 0.3mm Coppens, D₄ Combination of Coppens and Egg yolk and D₅ Artemia and Egg yolk. The increase in weight and length were measured weekly for four weeks using metre rule and sensitive weighing balance. The result are presented statistically using line graph and histogram. The fleshly bought eggs were cooked, and the shell and egg white were removed exposing the yolk. The yolk were mashed and sundried before mixing with Coppens and Artemia.

Results and Discussion

The results of the experiment are presented in figure 1, 2 and 3. There was an increase in the body weight and length of the fish. The larvae fed with Artemia had 0.014 to 1.2g, 0.5 to 3.2cm, egg yolk 0.014 to 1.3, 0.5 to 2.5cm, Coppens 0.014 to 5.1, 0.5 to 6.9cm, Coppens/egg yolk 0.014 to 6.4, 0.5 to 8.2cm and Artemia/egg yolk 0.014 to 4.4, and 0.5 to 5.7cm. The combination of Coppens and egg yolk had the best percentage survival 96%), followed by Coppens only 88%, Artemia and egg yolk 70%, Artemia 58% and the least was in egg yolk 50%. The water quality parameters were the same across the treatments.

The present study revealed differences in the growth rate of the *C. gariepinus* larvae fed different exogenous starter feeds. The larvae fed with 0.3mm Coppens and egg yolk gave the best performance in growth and survival this disagreed with (Faruk *et al.*, 2019) who previously reported best growth and survival in fish fed with Artemia. However, Onyia *et al.*,2017 reported that Artemia had the same growth performance with fishmeal, though it was less than that of livefood and combination of livefood and fishmeal. The survival rate was far better in Onyia *et al.*,2017, that had 63.3% compared to this present work with 58% using Artemia. The high growth can be as a

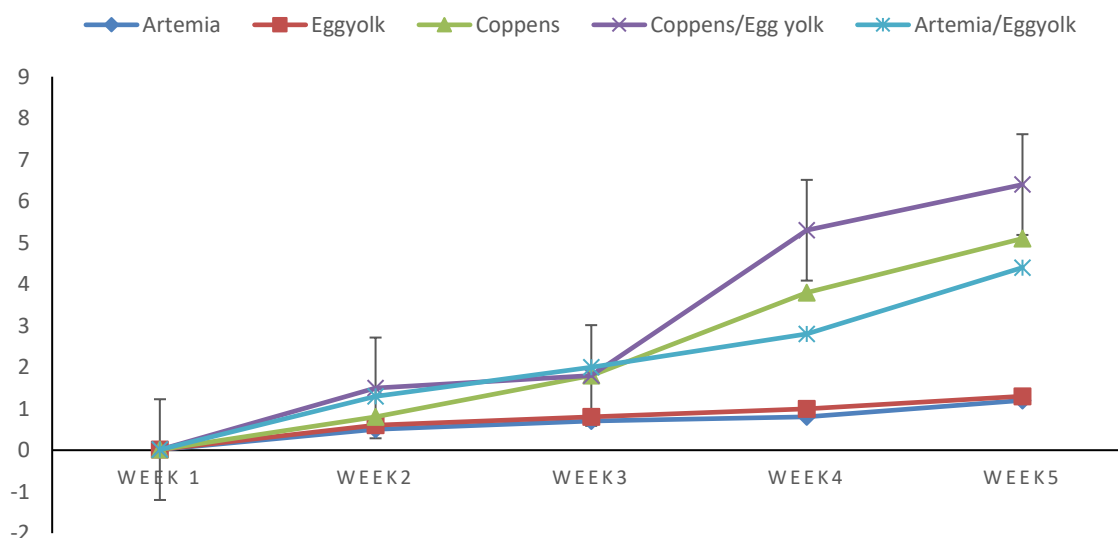


Figure 1: Weekly weight of *Clarias gariepinus* larvae fed with different starter feeds

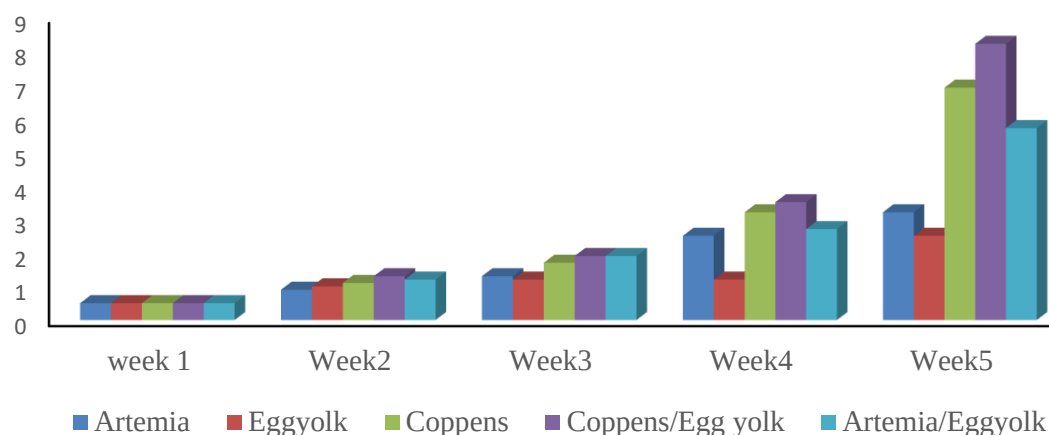


Figure 2: Weekly length of *Clarias gariepinus* larvae fed with different starter feeds

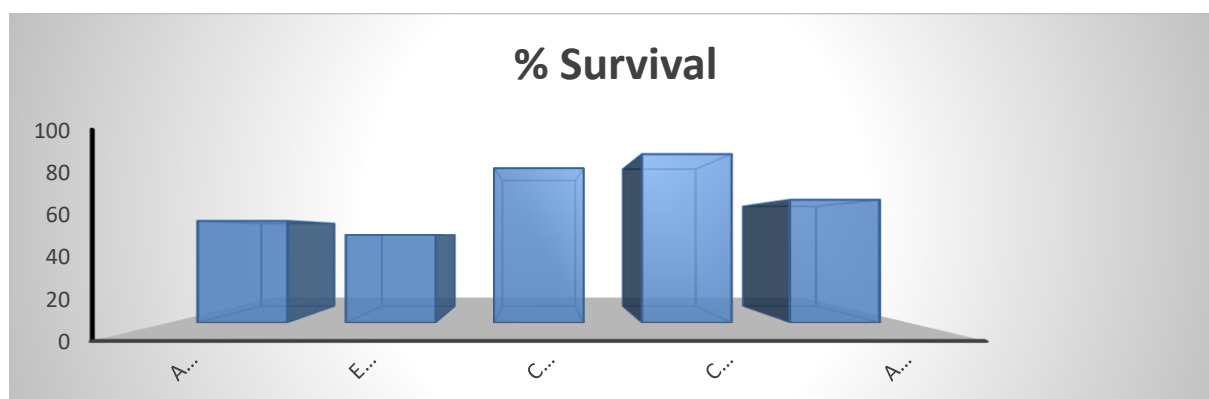


Figure 3: percentage survival of *Clarias gariepinus* larvae fed with different starter feeds

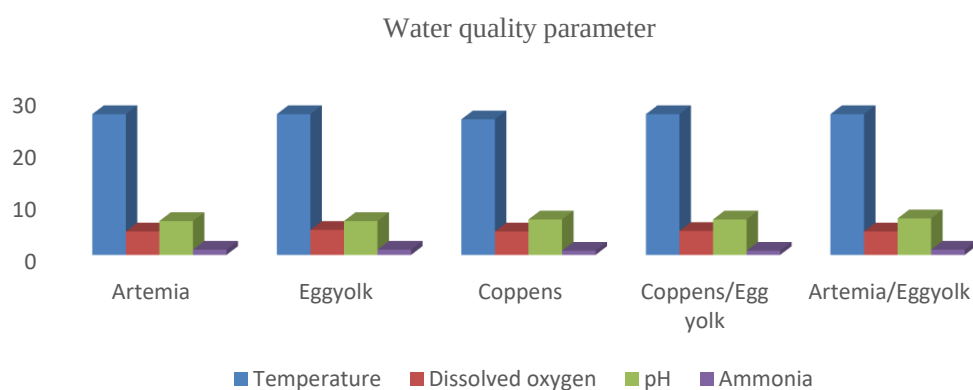


Figure 4. Water quality Parameters of *Clarias gariepinus* larvae fed with different starter feeds

result of balanced and quality of the Coppens in combination with egg yolk which contain vitamins, protein and lipid. Meanwhile, Egwenomhe *et al.* (2017) reported high growth in fish fed the combination of Artemia and egg white. Aruho *et al.* (2017) also exposed high growth on larvae fed with dry feed. The high survival recorded in the diet fed combination of 0.3mm Coppens and egg yolk could be as a result of the components contained in the egg yolk. The egg yolk contains Vitamin B₁₂ which is related with vitamin B₉, known as folate or folic acid (Mahmood, 2014), it increases the red blood cells which in turn increase the proficiency

of iron in the body of the fish. Folate((Mahmood, 2014)) and B₁₂ correlate to produce S-adenosylmethionine (SAME), a compound involved in immune function and healthy fish (Mahmood, 2014).

CONCLUSION

The research exposed the use of other starter feeds for growth of the fish. Coppens can be used to raise the larvae, also the combination of Coppens and egg yolk can yield a good result. It is cheaper and available for the fish farmers to use.

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PUSH EFFECT OF AQUACULTURE FISHERY ON NIGERIA'S DOMESTIC FISH PRODUCTION: A REVIEW

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ABSTRACT

Nigeria's fish production rate requires about 3.8 % increase annually in order to cater for national demand and *Clarias* (catfish) is the most cultivated. Aquaculture production grew from about 200,500 metric tons (mt) in 2020 to about 316,700 mt in 2015 but dropped to 291,300 mt in 2020 obviously due to the effects of COVID-19 pandemic. Mono-culture and flow-through systems are predominant. The study summarises that aquaculture can provide a better alternative to capture fisheries in view of the escalating facing social and economic factors facing Nigeria's capture fisheries.

Keywords: *Aquaculture, fish production, push-effect, fish demand, socio-economic factors*

INTRODUCTION

Aquaculture industry is the fastest-growing food-producing sector which accounts for approximately 50% of global fish production (Omeje *et al.*, 2020). Around 424 aquatic species are produced across the world, providing nourishment, sustainable livelihood, food security, and poverty reduction to millions of people (Galappaththi *et al.*, 2020). When compared to all other animal food production industries, the aquaculture industry continues to develop at an average global annual growth rate of 8.8% every year (Onada and Ogunola, 2017). With about 3.2 million mt of fish consumed yearly, Nigeria is adjudged the largest fish consumer in Africa and one of the world's major fish eaters (Adelesi, 2019). The most extensively cultured fish species in Nigeria include *Clarias gariepinus*, *Heterobranchus* spp., *Tilapia* spp., *Cyprinus carpio* (Common carp), and *Heterotis niloticus* (Slap water) (Omeje *et al.*, 2020). In the last decade, aquaculture production in Nigeria has grown to 291.3 thousand mt in 2020 thus placing Nigeria as the largest aquaculture fish producer in sub-Saharan Africa, accounting for 52% of the total farmed fish production in the region (WorldFish, 2018). However as reported by Dauda *et al.* (2018), Nigeria needs a 3.8% annual increase in fish production in order to meet the demands of its ever-increasing population. For over twenty-five years, there have been constraints in the Nigeria aquaculture systems, including inadequate infrastructure, insufficient supply of fish feed, irregular electricity supply, poor finance, high feed costs, land acquisition, high input prices, disease and poaching, poor extension services, poor market/price, poor hatchery facilities, and cannibalism (Adelesi 2019). Therefore the objective of this paper is to investigate the impact of aquaculture fishery on Nigeria's domestic fish production.

MATERIALS AND METHODS

Reports of several published works were reviewed with the view to assessing the potentials or otherwise of aquaculture in developing and sustaining Nigeria's fisheries industry. Also, several reports of FAO, FDF and the FMA were studied. Other information used were gathered from credible journals' publishing websites.

RESULTS AND DISCUSSION

In Nigeria, available statistical evidences indicated that the Country's capacity to satisfy local demand through capture fisheries cum aquaculture suffers setback each year as she continues to expend huge fiscal resources in fish imports. For example, Nwokedi *et al* (2020) quantified the financial resources spent by

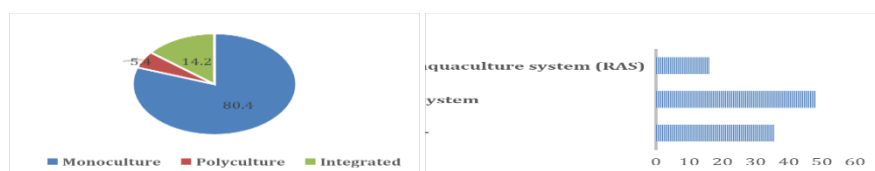


Figure 4a: Aquaculture Systems in Nigeria Figure 4b: Production Techniques in Aquaculture
Source: Emmanuel *et al.* (2014)

Further, findings of Nwokedi *et al.* (2020) revealed the yearly gaps in fish production from all sources and the aggregate demand for fishery resources in Nigeria between 2008 and 2017 (Table 1). The results showed that for all the years between 2008 and 2017, there existed deficits in fish supply from all local production sources when aggregated with the highest deficit of 368,994 mt of fish recorded in 2009 and the minimum short fall in supply of 177,525 mt recorded in 2017. The average deficit in fish supply from local output over the period was 292,348.6 mt per annum while the average yearly fish demand was 1,237,000 mt. This implies that the Nigeria fishery sub-sector is unable to satisfy about 24% of the aggregate fish demand within the economy. Given the increasing trend in population, in the coming years, the trend in supply gap is expected to continue, inducing more imports of fish with the associated disadvantages including capital flight (FAO, 2018). Thus viewed from per capita consumption point, Nigeria only satisfies 58% of each individual's yearly fish need from local production.

Table 5: Yearly Gap between Fish Demand and Production (output) in Nigeria (2008-2017).

Year	Actual Capture output(tonnes)	Actual Aquaculture output(tonnes)	Fish Demand	Supply Gap or Deficit per annum
2008	601368	143207	1090000	345425
2009	598210	152796	1,120,000	368994
2010	616981	200535	1150000	332484
2011	635486	221128	1180000	323386
2012	668754	253898	1220000	297348
2013	721355	278706	1250000	249939
2014	759828	313231	1290000	216941
2015	710331	316727	1320000	292942
2016	734731	306767	1360000	318502
2017	916284	296191	1390000	177525

Source: Nwokedi *et al.* (2020) adapted from FAO (2018)

CONCLUSION

Fish farming has been discovered to be a good alternative to fish provision from the wild (capture fisheries) which has been reducing in its capacity over the years due to several precarious situations as these traditional methods of capture fisheries have proven ineffective and are fraught with difficulties, including poor catch rate. Fish farming can help to alleviate poverty, promote food security and can provide alternative and affordable source of animal protein for human nutritional benefit. As a result, aquaculture may be a viable solution to the world's depleting fish supply. Even though the government is currently trying to deal with the multiple restraints affecting the aquaculture industry, the country has put in steps to enhance its aquaculture sectors, and there are a lot of potentials and prospects in the industry.

RECOMMENDATIONS

From the results of this investigation, the following recommendations are proffered:

- i. Government should make it a priority to develop aquaculture policy blue print as guide for the investment in/practice of aquaculture as a strategic way of ensuring sustainability of the sector.
- ii. Government should through the responsible agencies and ministries determine and map out mari-culture zones, within the sea locations and coastal zones in the Nigeria EEZ of the Atlantic see area.
- iii. Certification of fish farms, hatcheries, fish processing centres and feed mills must be done nationwide to ensure quality of fish products and reach for government's assistance including environmental, economic sustainability and social responsibility programmes.

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EFFECTS OF DIETARY SUNFLOWER (*Tithonia diversifolia*) LEAF EXTRACT ON GROWTH PERFORMANCE AND SERUM BIOCHEMICAL PROFILE OF AFRICAN CATFISH (*Clarias gariepinus*) FINGERLINGS

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ABSTRACT

This study investigated the growth performance and serum biochemical profile of *Clarias gariepinus* fingerlings. The fish were fed diets fortified with sunflower leaf extract (SLE) at 0.0 (positive control), 0.5, 1.0, 1.5 or 2.0 g/kg diet and the negative control diet containing 0.5 g synthetic antibiotic (A) /kg diet for 70 days. After the feeding trial, blood samples were collected from the fish for analysis of biochemical parameters using standard procedures. The data obtained were subjected to one-way analysis of variance and differences among means were established at $P < 0.05$. The weight gain, specific growth rate, nitrogen metabolism, and fish productivity index were significantly enhanced in fish fed SLE-based diets, compared to those fed the control diets. Higher protein efficiency ratio and lower feed conversion ratio were obtained in fish fed 0.5 – 1.5g SLE/kg diets, compared to those fed the control diets. The quadratic regression with respect to weight gain showed 1.13g/kg diet as the optimum inclusion level in *C. gariepinus*. The serum total protein, albumin, globulin, blood urea nitrogen and glucose were not altered significantly with dietary SLE. It could be concluded that sunflower leaf extract has growth-promoting property and its inclusion at 1.0g/kg diet is recommended for the optimum growth performance of *Clarias gariepinus*.

Keywords: *Clarias gariepinus*, sunflower leaf, growth performance, serum biochemistry

INTRODUCTION

The intensification of aquaculture has contributed immensely to the growth of the sector, accounting for about 52 % of fish for human consumption in 2018 while Nigeria is the second major producer of fish, majorly African catfish, in African region as well as the highest fish consumers (FAO, 2020). The continuous rise in the cost of feed ingredients is a major concern in the production of African catfish which is a fed species, with high protein requirements for optimum production while the intensive production of the fish is also associated with stress and application of chemotherapeutic agents to enhance production performance. However, the use of these synthetic drugs remains in fish tissues as residues and produce deleterious effects when consumed (Reverter *et al.*, 2017; Santos and Ramus, 2018).

Investigations of herbal additives as alternative to synthetic antibiotics has been on the increase in the recent years for fish production and several of these studies (Adeniyi and Lawal, 2017; Adeniyi, 2020; Adeshina *et al.*, 2021; Adeniyi *et al.*, 2021b) have shown that herbal additives could be efficacious alternative to the synthetic antibiotics.. Wild sunflower (*Tithonia diversifolia*) is a robust herbaceous and bushy perennial plant in the family Asteraceae. The plant is widely available and used in traditional medicine to solve health problems relating with wounds, ectoparasites, snakebites, muscular pain, malaria, diabetes, constipation, indigestion and sore throat. The medicinal roles of *T. diversifolia* have been associated with its biological activities, including antitumor, anti-hyperglycemic, anti-inflammatory and antimicrobial properties, among others (Ogunfolakan *et al.*, 2010; Zhao *et al.*, 2012; Abe *et al.*, 2015; Adeniyi *et al.*, 2021a). Compounds in the leaves of wild sunflower include terpenoids, alkaloids, lactones, phenols, flavonoids, and derivatives of trans-cinnamic acid (Chagas-Paula *et al.*, 2012; Abe *et al.*, 2015; Adeniyi *et al.*, 2021a). Despite the potentials of this plant, scientific information on its application as natural feed additive in aquaculture is

scarce, hence this study aimed to investigate the effects of *T. diversifolia* on the performance of *C. gariepinus* fingerlings.

MATERIALS AND METHODS

Source of the plant and extraction

Tithonia diversifolia (wild sunflower) leaves were obtained from a fallow land in a school compound in Ilorin, Kwara State, rinsed with clean water, drained, shade-dried at room temperature, and ground to fine powder using blender. The extraction was done at ratio 1 to 10 (plant to solvent, weight/volume) using 96% ethanol as described by Adeniyi *et al.* (2021b).

Experimental diets preparation and fish culture technique

All ingredients (fish meal, soybean meal, groundnut cake, corn flour, fish oil, dicalcium phosphate and fish premix) were processed to make the basal experimental diets (40 % crude protein) with the inclusion of SLE at 0.0 (positive control), 0.5, 1.0, 1.5 or 2.0 g/kg basal diets while 0.5g Aquamedics (a synthetic antibiotic containing oxytetracycline and erythromycin) constituted the negative control. The feed ingredients were thoroughly mixed, pelletized, dried using pelleting machine and stored in dried place until use. *Clarias gariepinus* fingerlings were obtained and acclimated for 14 days, during which they were fed with commercial floating feeds (1.8mm, Skretting, Nigeria). Thereafter, (360) three hundred and sixty fingerlings (4.37 ± 0.14 g) were randomly distributed into 18 plastic tanks (60 litre water capacity) at the rate of 20 fish per tank and fed the experimental diets to apparent satiation thrice daily for 10 weeks. The fish in each tank were daily monitored for mortality and batch-weighted before and after the experiment.

Evaluation of growth performance and feed utilization

The weight gain, specific growth rate, feed conversion ratio (FCR), protein efficiency ratio (PER), nitrogen metabolism, condition factor, fish survival and fish productivity index were calculated as described by Adeniyi *et al.* (2021b).

Blood collection and analysis

After the feeding trial, blood samples were collected from four fish in each replicate via the caudal vein into non heparinized bottles to allow the blood to clot and obtain sera samples. Blood biochemical parameters were analyzed in the sera samples using a commercial kit (Randox® Laboratories, Crumlin, County Antrim, UK), following standard procedures.

Statistical analysis

The data obtained were subjected to one-way analysis of variance while Duncan multiple range test was used to determine the level of significance among treatment at $P < 0.05$. Quadratic regression was used to determine the inclusion levels of SLE for optimum weight gain using statistical package for social sciences, version 23.

RESULTS AND DISCUSSION

Growth performance and feed utilization

The results show that the fish fed with SLE-fortified diets had enhanced ($P < 0.05$) final weight, weight gain, specific growth rate (SGR) compared to those fed the control diets (Table 1). The weight gain (%) rose with the increasing levels to a peak (798.55%) at 1.5g SLE/kg diets, the value of which almost doubles that of the fish fed the positive control diet. The quadratic regression showed 1.13g as the optimum inclusion level with respect to weight gain (Figure 1). Dietary SLE enhanced feed consumption, even though this was reduced significantly at 2.0g level among the SLE treatments. The FCR reduced ($P < 0.05$) with dietary SLE, even lower than the synthetic antibiotic-medicated diet, while on the other hand PER rose significantly at 1.0-2.0 SLE levels. Dietary SLE also enhanced ($P < 0.05$) nitrogen metabolism and fish productivity index while the fish condition factor and survival did not differ significantly among the treatments. The enhanced growth performance and the nutrients utilization observed in this study could be attributed to the presence of the

growth stimulants or phytochemical constituents such as alkaloids, flavonoids, phenol, saponin, terpenoids such as *sesquiterpene*, *monoterpenes* and *diterpenes* in the leaf extract of *Tithonia diversifolia* (Chagas-Paula *et al.*, 2012; Abe *et al.*, 2015; Adeniyi *et al.*, 2021a), which might have promoted feed digestibility, nutrients absorption and utilization resulting to the increased growth performance of the fish. Phyto-additives have been shown to enhance digestion of feeds due to increased production of bile acid, secretion digestives enzymes and villi absorption area (Adeniyi *et al.*, 2018; Shabana *et al.*, 2019; Adeniyi *et al.*, 2021b; 2022) responsible for enhanced feed digestion and utilization. The current study coincides with reports from recent studies (Fawole *et al.*, 2019; Adeniyi *et al.*, 2021b; Adeshina *et al.*, 2021; Adeniyi *et al.*, 2022) on the growth-promoting activity of herbal feed additives in fish culture.

Serum biochemical profile

The serum biochemistry profile showed that the serum total protein, albumin, globulin, blood urea nitrogen, and glucose were not altered significantly ($P < 0.05$) with dietary SLE (Table 2). However, *C. gariepinus* fed 0.5 A diet seemed to have the lower values of creatinine and total bilirubin, which did not differ from the values obtained at 1.0 - 2.0g SLE-based diets. Blood biochemical parameters are physiological indicators of fish health condition and usually use to test safety of test ingredients in fish nutrition. Albumin is significant for sustaining the osmotic pressure needed for proper distribution of substances while globulin contents are essential for maintaining a potential immune system and function in the blood ((Peyghan *et al.*, 2014)). The blood urea nitrogen, creatinine and bilirubin are metabolic nitrogenous waste products from the kidney; elevated levels of these metabolic wastes could indicate impaired glomerular filtration or severe tubular dysfunction (Brien and Walteson, 2009) in animals. The insignificant differences of these biochemical parameters could indicate safety of dietary SLE in *C. gariepinus* and the result is similar to previous studies (Farsani *et al.*, 2019; Fawole *et al.*, 2019).

Table 1: Growth performance and nutrient utilization of *Clarias gariepinus* fed varying levels of sunflower leaves extract (SLE) for 70 days.

Parameters	SLE levels (%)						Pooled SEM
	0.0	0.5 A	0.5	1.0	1.5	2.0	
Initial weight (g/fish)	4.35	4.23	4.53	4.43	4.17	4.48	0.053
Final weight (g/fish)	23.57 ^d	24.53 ^d	34.80 ^b	38.33 ^a	37.45 ^{ab}	30.47 ^c	1.466
Weight gain (g/fish)	19.22 ^d	20.30 ^d	30.27 ^b	33.90 ^a	33.28 ^{ab}	25.98 ^c	1.464
Weight gain (%/fish)	442.11 ^e	482.95 ^{de}	669.21 ^{bc}	764.49 ^{ab}	798.55 ^a	582.25 ^c	34.320
Specific growth rate (%/day/fish)	1.50 ^d	1.60 ^{cd}	1.97 ^{ab}	2.16 ^a	2.36 ^a	1.76 ^{ab}	0.031
Feed intake (g/fish)	25.10 ^b	24.53 ^b	34.49 ^a	35.33 ^a	34.90 ^a	28.47 ^b	1.205
Feed conversion ratio	1.31 ^a	1.21 ^b	1.14 ^{bc}	1.04 ^d	1.10 ^{cd}	1.10 ^{cd}	0.022
Protein efficiency ratio	1.92 ^d	2.07 ^c	2.19 ^{bc}	2.40 ^a	2.28 ^{ab}	2.29 ^{ab}	0.041
Nitrogen metabolism	536.42 ^d	552.75 ^d	755.79 ^c	821.76 ^a	799.60 ^{ab}	671.56 ^c	28.252
Condition factor	1.07 ^{ab}	1.06 ^{ab}	1.08 ^{ab}	1.10 ^{ab}	1.17 ^a	1.14 ^a	0.076
Fish Survival (%)	93.33	91.67	93.33	96.67	93.33	91.67	1.457
Productivity index	137.83 ^d	153.19 ^d	247.45 ^{bc}	315.75 ^a	283.75 ^a	216.02 ^{ab}	16.202

Mean with the different superscripts along the same row are significantly different ($P < 0.05$); A= Synthetic antibiotic

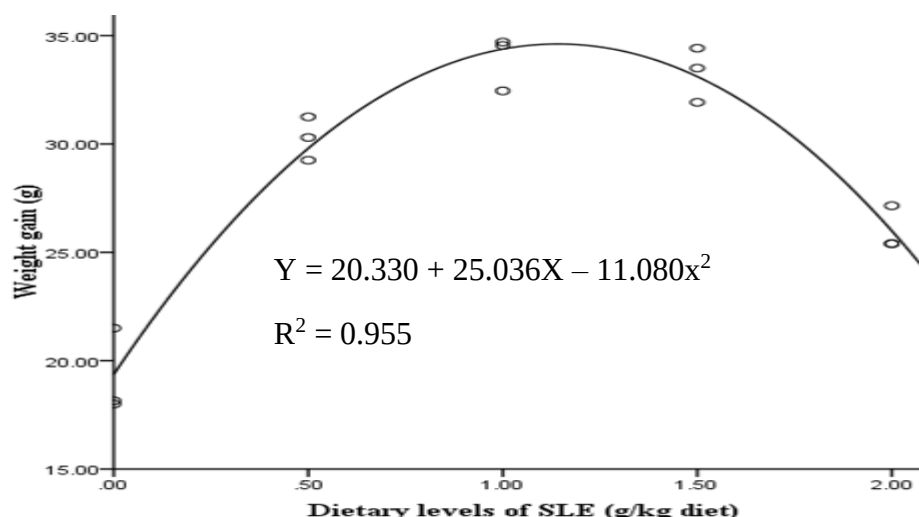


Figure 1: The relationship between dietary sunflower leaf extract (SLE) and weight gain of *Clarias gariepinus*

Table 2: Serum biochemical profile of African catfish, *Clarias gariepinus* fingerlings fed diets fortified with different levels of sunflower leaf extract (SLE) for 70 days.

Parameters	Levels of SLE (g/kg diets)						Pooled SEM
	0.0	0.5A	0.5	1.0	1.5	2.0	
Total protein (g/dL)	4.78	4.30	4.58	4.90	4.80	4.67	0.081
Albumin (g/dL)	1.28	1.03	1.23	1.15	1.30	0.97	0.049
Globulin (g/dL)	3.50	3.23	3.35	3.75	3.50	3.50	0.052
AGR	0.36	0.31	0.37	0.31	0.38	0.39	0.015
BUN (mg/dL)	7.13	6.75	7.00	6.95	6.83	6.80	0.072
Creatinine (mg/dL)	0.58 ^a	0.50 ^b	0.60 ^a	0.55 ^{ab}	0.55 ^{ab}	0.50 ^b	0.011
Glucose (mg/dL)	302.00	302.00	295.50	311.00	316.25	318.67	14.83
Cholesterol (mg/dL)	178.25 ^{ab}	171.25 ^b	175.00 ^{ab}	175.75 ^{ab}	179.50 ^{ab}	183.67 ^a	1.306
TB (mg/dL)	0.33 ^a	0.25 ^b	0.35 ^a	0.30 ^{ab}	0.30 ^{ab}	0.27 ^{ab}	0.012

Means with different superscripts along rows are significantly different at $P < 0.05$.

A, Antibiotic; AGR, Albumin globulin ratio; BUN, Blood urea nitrogen; TB, Total bilirubin

CONCLUSION AND RECOMMENDATION

The current study has shown that dietary sunflower leaves extract enhanced growth performance and nutrient utilization of *Clarias gariepinus* at the optimum inclusion level of 1.13g/kg diet. The study also demonstrated the insignificance differences in the serum proteins, urea nitrogen, creatinine and glucose. Therefore, it could be recommended that 1.0g/kg diet be utilized as organic feed additive in the production of *Clarias gariepinus*.

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GROWTH RESPONSE OF *Clarias gariepinus*, *Heterobranchus longifilis* AND THEIR HYBRIDS IN DADIN KOWA GOMBE, NIGERIA

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ABSTRACT

Inter-generic Hybridization between *Clarias gariepinus* and *Heterobranchus longifilis* was carried out simultaneously with post breeding management for eight weeks to determine the growth response between their hybrid and pure breed at Dadinkowa Gombe Nigeria. Three days old fry were transferred to plastic aquaria equipped with aeration system. The result of crossing between *Clarias gariepinus* and *Heterobranchus longifilis* reveals that; crosses of pure breed *Clarias gariepinus* has the fastest mean weight - length $13.67 \pm 5.68\text{g} / 9.51 \pm 1.96\text{cm}$ and then followed by crosses ($\text{Ht} \times \text{Cl}$) with mean weight - length of $8.02 \pm 3.52\text{g} / 7.36 \pm 1.81\text{cm}$. Therefore length and weight of the hybrids crossing between female *Heterobranchus longifilis* and male *Clarias gariepinus* ($\text{Ht} \times \text{Cl}$) shows that the intercept has value of 0.001 statistical significance for length gain and 0.003 statistical significance for weight gain. This result therefore confirms the possibility of breeding both the hybrid and pure breed of both *Clarias gariepinus* and *Heterobranchus longifilis* especially their reciprocal hybrid ($\text{Ht} \times \text{Cl}$) which can perform better in commercial aquaculture practice.

KEYWORDS

INTRODUCTION:

Clarias gariepinus is generally considered to be one of the best and most important tropical catfish species for aquaculture (Akinwale 2014). *Clarias gariepinus* and *Heterobranchus longifilis* are the two commonly cultured Catfish in Nigeria (Vanden and Bernacsek, 1990; Ojutiku, 2008). In Nigeria, fish and fish products contribute about 49% of animal protein consumed in the country (Akinwale 2014). *Clarias gariepinus* and *Heterobranchus longifilis* are widely cultured in Nigeria owing to their high market value and fast growing rate and ability to withstand adverse pond condition especially low oxygen content just as (Aluko and Ali, 2001) investigated that the hybrid of ♀ *Clarias gariepinus* and ♂ *Heterobranchus bidorsalis* and their parental species can be grown in commercial size in various type of culture system.

MATERIALS AND METHODS

Study Area: The project was conducted at fish hatchery facility of the Gombe State Ministry of Water Resources. Dadin-kowa fish farm is located about 35km east of Gombe town beside Hinna bridge along river Gongola in YamaltuDeba LGA of Gombe State Nigeria. It lies between latitude 10°18'00''N and longitude 11°30'00''. The Mature broodstock of known breeding record of *Clarias gariepinus* male (2.5kg), female (10kg) were obtained from Gombe state fish hatchery complex Dadinkowa while *Heterobranchus longifilis* male (4.3kg), female (13.5kg) were obtained from Wisdom farm Yola, Adamawa State Nigeria.

Experimental design

- i. *Clarias gariepinus*♀ x *Clarias gariepinus*♂ injected with Ovaprim
- ii. *Clarias gariepinus*♀ x *Heterobranchus longifilis*♂ injected with Ovaprim
- iii. *Heterobranchus longifilis*♀ x *Clarias gariepinus*♂ injected with Ovaprim
- i. *Heterobranchus longifilis*♀ x *Heterobranchus longifilis*♂ injected with Ovaprim

Where; ♀ = Female, ♂ = Male.

Procedure (Ovulation inducement): Four crosses of these species and their reciprocal crosses were carried out at Dadin Kowa fish farm hatchery complex according to Viveen *et al.*, (1985) method. The gravid females for both *Clarias gariepinus* and *Heterobranchus longifilis* were induced with Ovaprim hormone at 0.5ml/Kg body weight via intramuscular injection. After withdrawal of the needle, the fishes were then finger – rubbed to avoid back flow of the injected fluid. The induced fishes were kept in a 200L plastic tank containing clean water at temperature range between 27°C- 28°C for ovulation and maturation of gonads.

Stripping of the female brood stock

The females were stripped into a dry clean plastic bowl. The male brood fishes were sacrificed for their milt. Milt was then squeezed into 10ml beaker containing 1 - 2ml of 0.9% saline solution after dissection of the testes. Stripped eggs were then mixed with the milt for fertilization. The resulting mixture was then stirred using a chicken feather for one minute to ensure complete fertilization then quadruplet's batches of the eggs from each cross were placed in plastic ponds/tanks for incubation (Viveen *et al.*, 1985).

Incubation of fertilized eggs: Incubation of fertilized eggs was carried out in four (4) plastic tanks of 500l capacity. The eggs were spread on Nylon mesh (1mm for *Clarias gariepinus* ova and 2 mm for *Heterobranchus longifilis* ova) suspended at the floor for incubation. The eggs were observed to hatch after 22 – 26 hours later at 28°C water temperature. Hatchlings were noticed swimming around the spawning mat. After the larvae absorbed their yolk, the plastic tank was then cleaned by siphoning out the dead eggs using siphon tube and the removal of the spawning mat. Three days from hatching, fry were fed to satiation with a crushed 0.2 mm-0.3 mm Coppens feed for 7 days then followed with partially crushed for another 7 days (Fondries, 2017; Surajit and Tapas, 2014).

Sorting/Grading: Grading is aimed at separating the bigger fry from the smaller ones in the hatchery by the means of eye observation so as to suppress cannibalism by the bigger fry, also known as; shooters or jumpers (Olufeagba and Okomoda, 2016).

Growth response: The size of fry increased with corresponding increase in egg size (Bichi *et al*, 2014). Monitoring of the embryonic development was done every 10min. until the morula stage is attained; afterwards, it was done on an hourly base. Identification of the embryonic stages and timing were carried out according to the method adopted by (Olufeagba *et al.*, 2016).

Analysis of growth: Weight gain = $W_1 - W_0$ (mg), Absolute growth rate (AG), express as weigh gained per period was calculated using woods *et al.*, (1983) . Growth rate = $W_1 - W_0 / t$. Condition factor (K) to determine the relative robustness was estimated for each growth period, according to the equation by Lagler (1956). $K = W \times 10^5 / (L)^3$ where $W_1 = (W_0 \times F/C)$,

Results and Discussion

The growth performance of *Clarias gariepinus*, *Heterobranchus longifilis* and their hybrid in plastic aquarium in Dadinkowa Gombe State is shown in the crossing between female *Heterobranchus longifilis* and male *Clarias gariepinus*, Cl x Cl represent crossing between female and male *Clarias gariepinus* and Cl x Ht the crossing between female *Clarias gariepinus* and male *Heterobranchus longifilis*. This result indicated that the initial weight of Cl x Cl, Ht x Ht, Cl x Ht and Ht x Cl were recorded as 0.007g, 0.02g 0.26g and 0.013g respectively. Whereas the final mean weight of (13.68±5.69g) was recorded in pure breed (Cl x Ht), followed by hybrid (8.03±3.52g) Ht x Cl while Ht x Ht pure breed gave the lowest final mean weight gain of (5.39±2.68g)

Fish growth performance: The differences in mean length per week between pure breed and hybrid increase rapidly within the period of this study. At initial fish length for both pure breed and hybrid were all less than 1.5cm which indicated that the growth by length of pure breed ♀Cl x ♂Cl and hybrid ♀Ht x ♂Cl were higher than

Table 1: Growth response of *Clarias gariepinus* and *Heterobranchus longifilis*.

Metric	Cl X Cl	Ht X Ht	Cl X Ht	Ht X Cl
Mean initial weight (mg)	0.007±0.01	0.02±0.01	0.26±0.01	0.013±0.01
Mean final weight (mg)	13.68±5.69a	5.39±2.68b	7.85±3.66c	8.03±3.52c
Weight gain (mg)	13.67±5.68a	5.37±2.67b	7.59±3.65c	8.02±3.52c
Mean initial length (cm)	1.26±0.01	1.23±0.01	1.13±0.01	1.33±0.00
Mean final length (cm)	9.51±1.96	5.89±1.61	6.76±1.92	7.36±1.81
Length gain (cm)	8.25±1.95	4.66±0.01	5.63±1.91	6.03±1.81
Growth rate (mg/d)	0.24±0.0a	0.09±0.0b	0.14±0.01c	0.14±0.0c
Specific growth rate	0.76±0.0a	0.33±0.0b	0.45±0.0c	0.46±0.0c
Survival (%)	95±0.0a	90±0.0a	60±0.0c	80±0.0b

Mean±SE values in the same row with different superscripts differ significantly (p<0.05)

the crosses of pure breed *Heterobranchus longifilis* and hybrid ♀Cl x ♂Ht. The finding of the current study disagrees with the finding of Aluko, (1995) who reported that crossing female *Clarias gariepinus* with male *Heterobranchus longifilis* result to a heavier and longer F1 generation than their reciprocal cross as well similar to Ndome and Obiekezie, (2009) whom indicated that in terms of growth in length, the cross Cl x Ht has the highest growth response.

Changes in fish weight: Similarly, pure breed of *Clarias gariepinus* has the fastest mean weight 13.67±5.68g, and then followed by the cross ♀Ht x ♂Cl with mean weight 8.02±3.52g down to ♀Ht x ♂Ht with mean weight of 5.37±2.67g. This is in agreement with Ataguba, *et.al.*, (2010) whom reported that in terms of final mean weight the crossing of female and male *Clarias gariepinus* has a significance higher

weight than the other crosses of Cl x Ht, Ht x Ht, and Ht x Cl respectively. Therefore crossing between female *Heterobranchus longifilis* and male *Clarias gariepinus* may yield better result in out-growing pond. The variation in the final mean weight gain could be due to difference in the environment and the species physiology. Therefore, the Cl x Cl has the fastest growth rate over the period of eight weeks.

CONCLUSION:

Clarias gariepinus, *Heterobranchus longifilis* and their hybrid can breed and cultured successfully in this region of the Sudan Savannah. The growth response, the pure breed *Clarias gariepinus* perform better than the other crosses and was followed closely by the hybrid cross of female *Heterobranchus longifilis* with male *Clarias gariepinus* which performed better than the other hybrid cross Cl x Ht and the pure breed cross Ht x Ht respectively.

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INFORMATION MANAGEMENT SYSTEM IN AQUACULTURE PRODUCTION

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ABSTRACT

The efficient operation of aquaculture farm management depends on accurate and user-friendly information management systems. To this end, an integration of information systems is needed to help aquaculturists keep records of production, sales, and farm inventories or machinery. This will aid accountability and accurate data collection for effective farm business management. A new web-based application was created as a result to accommodate this evolving need. The boundaries and scope of the application are described in terms of actors and functionalities, where actors are entities interfacing with the system. A conceptual model was created based on the data gathered and the Soft System Methodology (SSM). As a framework for creating the specific requirements for the farm information management system, the application components were presented as parts of rich pictures and connected to the conceptual model of the overall application that was subsequently derived. The created application replaces the manual method of maintaining sales and accounting records and aids the fish farming sector in managing fishing production through accurate data collection, stock processing, and accountability.

KEYWORDS: Control System, Aquaculture, Management, Fish Farm, Information System

Introduction

Nigerian fishermen have used traditional fish culture techniques in tidal pools and flood plains for many years (Gomna *et al.*, 2020). However, fish farming was introduced to the nation due to the need to increase food production, particularly animal protein. Aquaculture, or fish farming, is a practical supplement to the declining fish supply from captured fisheries (Adewumi and Olaleye, 2011). According to Adedeji and Okocha (2011), aquaculture production is a profitable industry in Nigeria. Still, it requires more effort from the general public and the government to improve its management to close the gap between the nation's demand for fish and supply. Thus, by providing adequate farming records through the application of sensible management techniques, there will be increases in production, fish quality, and marketability. The way society accesses and analyses information is changing due to the internet. Scientists and extension specialists believe that although farmers now have access to a variety of information about various aspects of their farming systems, many lack the technical innovation skills needed to use that information to increase their farms' profitability and sustainability (Climaco *et al.*, 2013). Therefore, this study aims to create a web-based application to aid in managing records, inventories, and regular business operations in aquaculture production.

Materials and Methods

Application development

The application was developed in the form of a database using a Relational Database Management System (RDBMS). The decision to implement the application as a database was motivated by the recognition that various types of data would need to be held, and that a database approach would be more appropriate given the benefits of the database file system over other types of file systems.

Analysis of the existing system and its limitations

A preliminary investigation into Muda's fish farming was conducted to learn more about their operational procedures. The fish farm owned by Muda is situated in Adamawa State, Nigeria, in the Yola, Yola south area. According to the investigation, computerised systems are not used at Muda's fish farm; everything is done by hand. They used paper and pencil to keep track of all of their processing, sales, transactions, calculations, and other activities. Manual record keeping required a lot of paper and space, and retrieving records became difficult while their storage and processing posed a security risk. The work required a lot of effort and time, which ultimately led to numerous errors and mistakes.

Application's functional and non-functional requirements

The new application had to be able to manage sales, maintain records of sales and expenses, maintain data on staff, maintain records of customers and their transactions, and generate receipts for any transactions as well as reports as needed. The system's security, logging, storage, configuration, performance, flexibility, and accessibility were the non-functional requirements.

Input and output specifications

The responses obtained from the interview with the manager and staff of Muda's fish farm serve as the input specifications for the developed application. These inputs were used in the creation of the fish farm management system as well as its implementation. The user interfaces that interact with users and gather data, like sales details or new employee record details, to be processed and produce output, like transaction receipts or report statements of the operations of the farm, are the developed application's output specifications.

Program design

The top-down method was used to design the study's programme. The entire issue with the current system was segmented into smaller problems and dealt with differently. To create visual representations of object-oriented software systems, the Unified Modelling Language (UML), a general-purpose modelling language standardised in object-oriented software engineering, was used. The decision to use UML was made following a study by Engels *et al.* (2000), which claimed that UML combines techniques from data modelling, business modelling, object modelling, and component modelling and can be used throughout the software development life-cycle and across various implementation technologies. The developed algorithm is represented graphically in the flowchart in Figure 1.

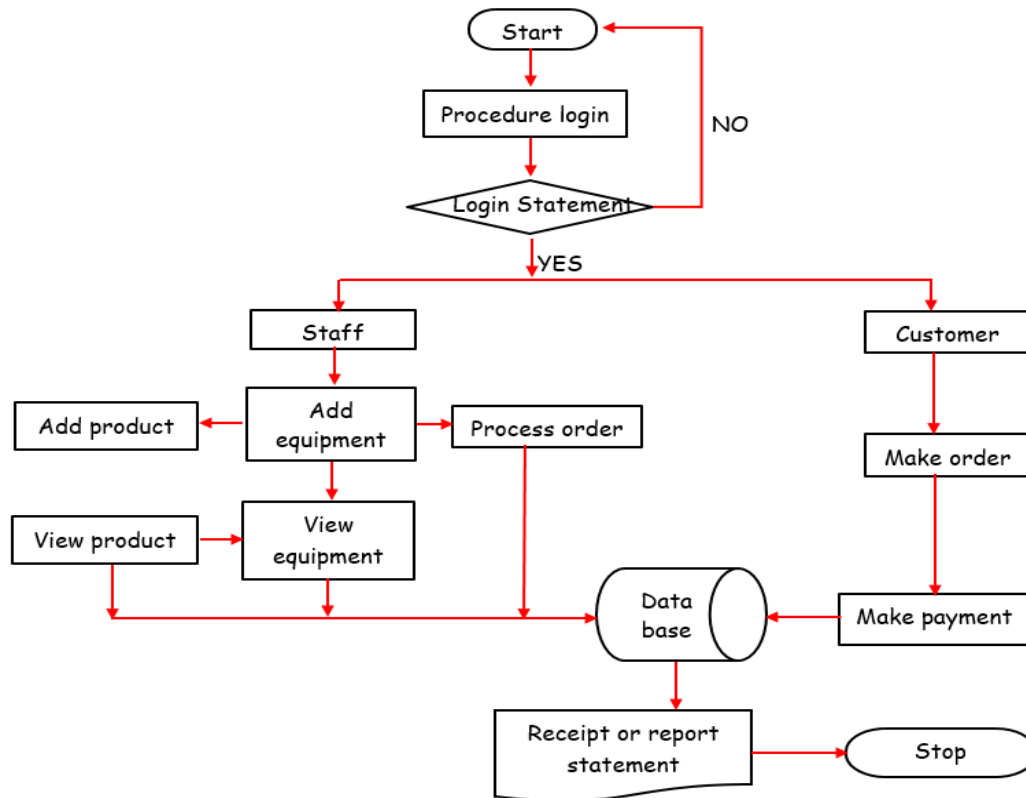


Figure 1: Flowchart of the developed algorithm

Results and discussion

The new application developed

The newly created application is a web-based programme that, when connected to the internet, can be used by any web browser. When necessary, the application generated reports for the transactions, expenses, and staff records and managed the staff records. It manages expenses and sales operations, print reports and produces receipts for every transaction. Additionally, the system enables customers to place orders right from their doorstep, saving them the trouble of travelling to the fish farm. The system produced reports for the transactions and assisted with sales management and record keeping.

The use case diagram of the developed application

Figure 2 shows the use case diagram, which describes the system application's business and step-by-step operational workflows of components. The fundamental idea of use case modelling is its ability to assist in system design from the end user's standpoint. Thus, describing all externally visible system behaviour is valuable for explaining system behaviour to users.

System Implementation

The scripting language Hypertext Preprocessor (PHP) was used to implement the system. The site definition, which involves preparing, selecting a browser, and putting a structure in place for the folder and folder structure

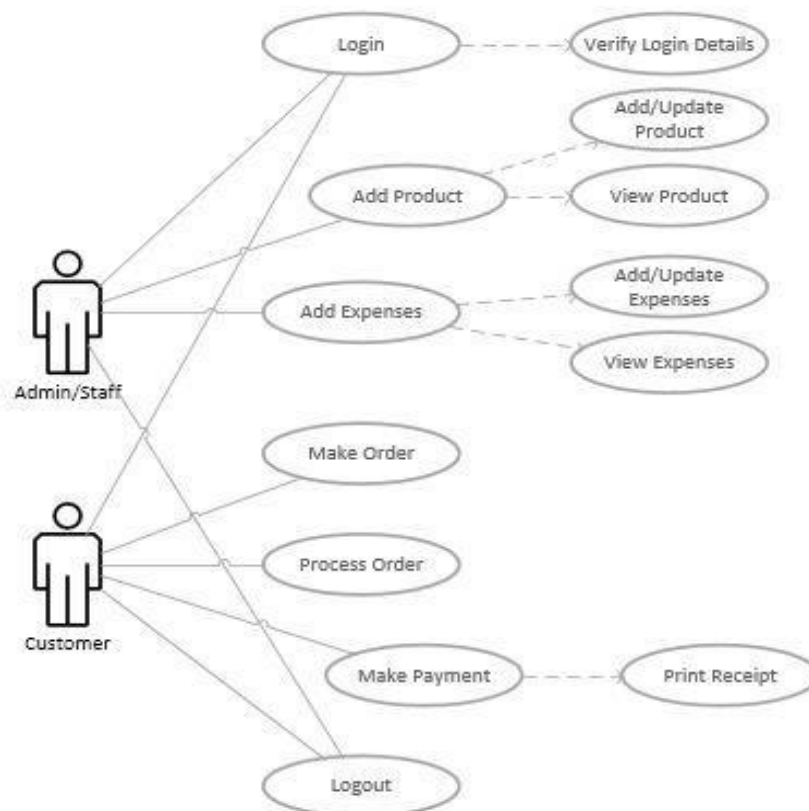


Figure 2: Use case diagram of the developed application

that will be used to store the site files served as the foundation for the implementation. The next stage of the implementation phase involved translating the design into the necessary forms. The database's necessary tables were all constructed, and data binding was carried out using HTML code, PHP, and Structured Query Language (SQL).

Front and back end Implementation

The front end was implemented using HTML, CSS, and Bootstrap 4 for design purposes and coding environments. The Muda's fish farm record management system was implemented using MySQL server and PHP as a back-end tool for the implementation.

Application testing

The developed application was tested with various tasks involved in aquaculture production to see how it functions and identify any potential issues. The output interface of the created app is shown in Figure 3. Integration testing was used, where every component was put together and tested to ensure that it functions appropriately. The test was run on a machine that wasn't used to create any specific pieces of code to get an accurate result. Testing shows that the software functions seem to be functioning as intended and that the behavioural and performance requirements seem to have been satisfied.

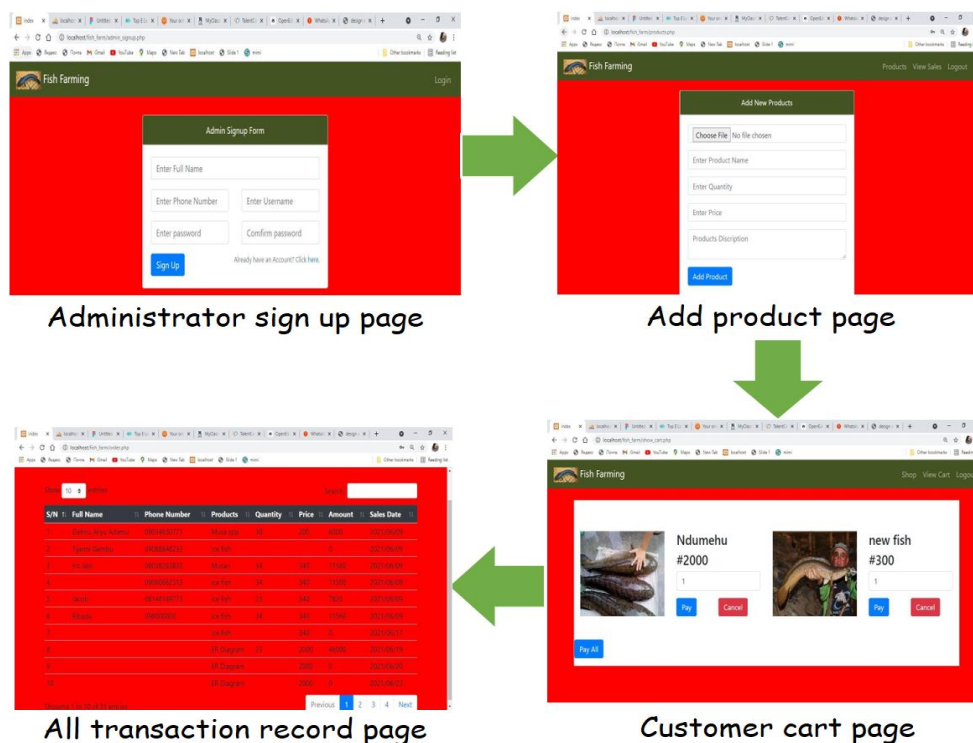


Figure 3: The output interface of the developed app.

Conclusions

The developed application offers a substitute for the manual method of keeping sales and accounting records, and it helps the fish farming industry in the areas of stock processing, accountability, and accurate data collection for managing fishing production. It also offers a way to create a report of the daily activities involved in farming. This enhanced the fish farming operation's integrity, dependability, security, and traceability.

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HAEMATOLOGICAL PROFILE OF HYBRID CATFISH (*HETEROBRANCHUS LONGIFILIS* X *CLARIAS GARIEPINUS*) JUVENILE EXPOSED TO PROBIOTICS IN CULTURE WATER

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ABSTRACT

Probiotics are used as an alternative to the prophylactic use of antibiotics. The study was aimed to evaluate haematological status of hybrid catfish (*Heterobranchus longifilis* male X *Clarias gariepinus* female) juvenile exposed to probiotics in culture water for 56 days. A total of 120 hybrid catfish (Initial length 30.52 ± 3.33 cm and weight 215.40 ± 66.71 g) were allocated in triplicate to 12 experimental tank (10 fish/tanks: 30 fish/treatment). Hybrid catfish were exposed weekly to probiotics (dried *Bacillus* spp, 5×10^9 cfu/grams; trade name: remediate, company name: Zeigler) in culture water to control 0.0 mg/l and 0.5, 1, 1.5 mg/l as HMS=half of manufacturers subscription, MS=manufacturers subscription and AMS=above manufacturers subscription respectively. Blood samples were collected weekly from individual fish for haematological profile. The results showed that there were no overall significant differences (ANOVA, $p > 0.05$) between treatments in the measured water quality parameters (Temperature ($^{\circ}$ C), dissolved oxygen (mg/l), pH, Nitrate (mg/l), nitrite (mg/l) and ammonia (mg/l)), values were within the recommended range for catfish. Likewise for the all the blood parameters (Packed cell volume (PCV), haemoglobin (HB), Red blood cells (RBC), platelet, neutrophil, lymphocyte, eosinophil, monocyte) measured, there were no observed significant differences (ANOVA, $p > 0.05$) between treatments apart from the white blood cells that showed transient significant difference on day 7, where the MS (8.75 ± 0.35) and AMS (9.25 ± 0.35) treatments were significantly increased compared to the HMS (6.75 ± 0.07) and control (4.10 ± 0.14). In conclusion, probiotics (dried *Bacillus* spp, 5×10^9 cfu/grams; trade name: remediate, company name: Zeigler) as used in this study showed no effect on the haematological profile on hybrid catfish.

Keywords: Dried *Bacillus* spp, remediate, aquaculture, full blood count, disease

Introduction

Aquaculture is seen as one of the important sectors for food security for a growing global human population. To meet up with fish demand, aquaculture has adopted intensive culture systems that are associated with increased productivity per unit area as a result of high stocking rate (Basha et al., 2013). The intensification of aquaculture practices has resulted to fish exposed to diseases, which consequently results to mortality, retarded growth and overall decreased production (Reverte et al., 2014) resulting in a significant set-back on aquaculture (Hai 2015). Effective control of disease is one of the vital elements in successful aquaculture. Over the years, antibiotics had been traditionally used to improve growth, resist diseases and improve the quality and sustainability of cultured fish (Hassan et al., 2014; Li et al., 2006). However, the misuse of antibiotics has caused a prevailing resistance among pathogenic bacteria, downgrading of environmental factors (Bachère, 2000), as well as introduction of harmful residues that are not safe for human consumptions (Hassan et al., 2014). One of the methods considered to improve the quality and sustainability of aquaculture is the use of probiotics (Li et al. 2006).

Probiotics is defined as live microorganisms that, when administered in adequate amounts, confer a health benefit on the host (Sanders, 2008). Probiotics such as *Lactobacillus*, *Bacillus*, *Saccharomyces* species and their mixture have been effectively used in aquaculture production through oral/water or mixture in feed supplement (e.g., Akanmu, 2016); to promote good water quality, fast growing, environmental tolerant and disease free fishes safe for human consumption (Hassan et al., 2014). Several research work with probiotics has been reported. For example, probiotics have been reported to enhance development in *Oreochromis niloticus* (Imanet et al., 2014), increase immune-system in *Cyprinus carpio* (Sorouch, 2011), improve wound healing in *Clarias gariepinus* (Erazor-Pagador, 2001) and *Heterobranchus bidorsalis* (Akanmu et al., 2016), improve water quality (Cha et al., 2013), used as biological control medium against *Aeromonas hydrophila* in *Catla catla* (Parthasarathy and Ravi, 2011). Haematological status is one of the key tools to assess the health status of fish (Amachree and Emmanuel, 2022). The measurement of blood

parameters is used as a tool for monitoring the physiological state of fish in response to changes related to nutrition, water quality, disease and other stress factors on fish health (Bell-Olusojiet *al.*, 2006). Changes in haematology of fish are indicators of the stress stage of fish, producing useful information to check any unfavourable condition that may affect overall fish health. The study was aimed to evaluate haematological status of hybrid catfish (*Heterobranchus longifilis* male X *Clarias gariepinus* female) juvenile exposed to probiotics in culture water for 56 days.

Materials and Methods

Experimental Area, Experimental fish Procurement and Acclimation

The experiment was carried out at the African Regional Aquaculture Centre (ARAC)/Nigerian Institute for Oceanography and Marine Research (NIOMR), Aluu, Port Harcourt, Rivers State, Nigeria. One hundred and twenty juveniles of hybrid catfish (*Heterobranchus longifilis* male x *Clarias gariepinus* female) of the same stock was procured from ARAC/NIOMR and moved to experimental tanks and acclimated for two weeks. During acclimation, fish were fed to visual satiety twice daily (Davies *et al.*, 2006). The commercial feed and probiotic (dried *Bacillus* spp., 5×10^9 cfu/gram; trade name: Remediate; company name: Zeigler) were procured from farm foods, Rumuokoro, Port Harcourt.

Experimental Design and Probiotics Inclusion into Culture Water

Following acclimation, hybrid catfish (Initial length 30.52 ± 3.33 cm; weight 215.40 ± 66.71 g) were randomly stocked in pre-labelled 12 concrete tanks (97 x 97 x 96 cm each) representing three treatments (0.5, 1, 1.5 mg/l) including the control (0.0 mg/l) in triplicate design (10 fish/tank; 30 fish/treatment). The treatments 0.0, 0.5, 1, 1.5 mg/l are defined as c=control, HMS=half of manufacturers subscription, MS=manufacturers subscription and AMS=above manufacturers subscription respectively. After acclimation, probiotic (dried *Bacillus* spp., 5×10^9 cfu/gram) was introduced into the culture water according to the treatments, culture water was renewed weekly. The experiment lasted for 56 days (i.e., eight weeks) and fish were fed to satiety twice daily with commercial diet.

Fish sampling for Full Blood Count

Full blood count was done as earlier described (Amachree and Emmanuel, 2022). On days 0, 7, 14, 28 and 58, Individual fish were caught with a hand net and blood was collected with 5 ml disposable syringes and 21-gauge hypodermic needle and preserved in purple bottle containing ethylenediaminetetraacetic acid (EDTA). Thereafter, samples were taken to a reputable laboratory in ice box for analysis.

Data Analysis

The data obtained from the study were analyzed using the Minitab version 16 for windows. Data were pooled by treatment and presented as means + standard deviation (SD) for $n = 30$ fish/treatment unless otherwise stated. Data were analysed for treatment or (and) time effect by one or two-way analysis of treatment, time, and treatment x time interactions. Where the test showed statistically significant treatment x time effect ($p < 0.05$), the one-way ANOVA was used to test for treatment effects within a time or effect within the treatment. The Turkey's post-hoc test at 95% confidence limit was used to provide specific information on which means are significantly different from each other.

Results and Discussion

There were no significant differences ($p > 0.05$) observed in probiotic treatments and the control for all the water quality parameters (Temperature ($^{\circ}\text{C}$), dissolved oxygen (mg/l), pH, Nitrate (mg/l), nitrite (mg/l) and ammonia (mg/l)) measured, values were within the recommended range for catfish.

The results of the weekly full blood count are shown on Table 1. There were no observed significant differences ($p > 0.05$) in probiotic treatments compared to the control apart from the white blood cells that showed transient significant difference on day 7. On day 7 (data not shown), the MS (8.75 ± 0.35) and AMS (9.25 ± 0.35) treatments were significantly increased compared to the HMS (6.75 ± 0.07) and control (4.10 ± 0.14).

Probiotics was introduced to improve water quality in aquaculture. Studies with *Bacillus* spp. has shown to improve water quality and enhance fish immune response (Elsabaghet *al.*, 2018). However, the result of the present study was contrary to those reported earlier. In the present study, inclusion of probiotics (*Bacillus* spp.) in culture water did not show any effect between the treatments.

Probiotics improve haematological parameters. Although, results from this study did not show any changes in haematological profile in all treatments including the controls it is contrary to Ayoola *et al.* (2012) who reported increased levels of blood parameters at 90 days trial. The difference for this might be as a result of the duration of the experiment. However, according to Ayoola *et al.* (2012) there were increases in the blood parameters measured, all blood parameters obtained were within the ranges recommended for fish blood.

Table 1. Haematological Profile of hybrid catfish after 56 days in probiotics inclusion culture

DAY	PARAMETERS	TREATMENTS			
		C	HMS	MS	AMS
0	PCV (%)	32.50 ± 3.54 ^a	32.00 ± 1.41 ^a	30.00 ± 4.24 ^a	36.50 ± 0.71 ^a
	HB (g/dl)	10.85 ± 1.20 ^a	10.65 ± 0.49 ^a	10.00 ± 1.41 ^a	12.15 ± 0.21 ^a
	RBC (*10 ¹²)	4.25 ± 0.35 ^a	4.25 ± 0.07 ^a	4.25 ± 0.64 ^a	5.25 ± 0.35 ^a
	WBC (*10 ⁹)	6.00 ± 0.28 ^a	6.10 ± 0.85 ^a	4.65 ± 0.21 ^a	5.60 ± 0.14 ^a
	Platelet (*10 ⁹)	151.50 ± 4.95 ^a	203.50 ± 16.25 ^a	181.50 ± 9.19 ^a	258.50 ± 54.45 ^a
	Neutrophile (%)	26.00 ± 1.41 ^a	24.00 ± 8.49 ^a	13.50 ± 2.12 ^a	29.00 ± 1.41 ^a
	Lymphocyte (%)	61.50 ± 2.12 ^a	63.50 ± 2.12 ^a	71.00 ± 1.41 ^a	64.00 ± 5.66 ^a
	Eosinophile (%)	4.00 ± 1.41 ^a	4.00 ± 1.41 ^a	4.00 ± 1.41 ^a	2.50 ± 0.71 ^a
	Monocyte (%)	8.50 ± 2.12 ^a	8.50 ± 4.95 ^a	6.50 ± 2.12 ^a	4.50 ± 3.54 ^a
28	PCV (%)	40.00 ± 2.83 ^a	35.50 ± 3.54 ^a	34.50 ± 6.36 ^a	39.00 ± 4.24 ^a
	HB (g/dl)	13.50 ± 2.12 ^a	13.35 ± 0.92 ^a	11.50 ± 2.12 ^a	13.00 ± 1.41 ^a
	RBC (*10 ¹²)	5.85 ± 0.49 ^a	5.05 ± 0.35 ^a	5.05 ± 1.34 ^a	5.70 ± 0.85 ^a
	WBC (*10 ⁹)	5.35 ± 1.63 ^b	7.00 ± 0.28 ^b	8.80 ± 0.14 ^{ab}	11.15 ± 0.49 ^{a#}
	Platelet (*10 ⁹)	219.00 ± 5.66 ^b	253.50 ± 12.02 ^{ab}	240.50 ± 4.95 ^{ab}	278.50 ± 23.33 ^a
	Neutrophile (%)	31.00 ± 5.66 ^a	35.00 ± 7.07 ^a	43.50 ± 2.12 ^{a#}	37.00 ± 1.41 ^a
	Lymphocyte (%)	60.00 ± 7.07 ^a	55.00 ± 7.07 ^a	47.50 ± 0.71 ^a	52.50 ± 3.54 ^a
	Eosinophile (%)	3.00 ± 0.00 ^a	3.00 ± 1.41 ^a	3.50 ± 0.71 ^a	3.00 ± 1.41 ^a
	Monocyte (%)	6.00 ± 1.41 ^a	7.00 ± 1.41 ^a	5.50 ± 0.71 ^a	7.50 ± 3.54 ^a
56	PCV (%)	39.50 ± 7.78 ^a	39.50 ± 4.95 ^a	40.50 ± 2.12 ^a	44.00 ± 1.41 ^a
	HB (g/dl)	13.15 ± 2.62 ^a	13.15 ± 1.63 ^a	13.50 ± 0.71 ^a	14.65 ± 0.49 ^a
	RBC (*10 ¹²)	5.40 ± 1.56 ^a	5.85 ± 1.20 ^a	6.10 ± 0.14 ^a	6.30 ± 0.28 ^a
	WBC (*10 ⁹)	6.60 ± 2.69 ^a	7.10 ± 0.85 ^a	8.85 ± 0.49 ^a	11.35 ± 0.92 ^a
	Platelet (*10 ⁹)	189.50 ± 30.41 ^a	242.50 ± 6.36 ^a	261.50 ± 9.19 ^a	261.50 ± 19.09 ^a
	Neutrophile (%)	38.50 ± 4.95 ^a	37.00 ± 1.41 ^a	33.00 ± 1.41 ^a	31.50 ± 1.41 ^a
	Lymphocyte (%)	54.00 ± 5.66 ^a	54.00 ± 1.41 ^a	59.00 ± 1.41 ^{a#}	58.50 ± 4.95 ^a
	Eosinophile (%)	2.50 ± 0.71 ^a	3.00 ± 1.41 ^a	2.50 ± 0.71 ^a	3.50 ± 0.71 ^a
	Monocyte (%)	5.00 ± 0.00 ^a	6.00 ± 1.41 ^a	5.50 ± 0.71 ^a	6.50 ± 0.71 ^a

Data are means ± STD for n=3. Different letters within a day indicates statistical significant difference (ANOVA, $p < 0.05$) between treatments. # indicates a significant time effect within a treatment compared to the previous day (ANOVA, $p < 0.05$). Note C=control; HMS=half of manufacturer subscription; MS=Manufacturer's subscription and AMS= above manufacturer's subscription.

CONCLUSION

In conclusion, probiotics (dried *Bacillus spp*, 5x10⁹cfu/grams; trade name: remediate, company name: Zeigler) as used in this study showed no effect on the haematological profile on hybrid catfish.

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EFFECT OF REPLACING SOYABEAN WITH *LEUCENA LEUCOCEPHALA* LEAF MEAL ON THE GROWTH PERFORMANCE OF *HETEROBRANCHUS LONGIFILIS* JUVENILES.

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ABSTRACT

Leucaena leaf meal (MLM) is a source of protein from the plant *Leucaena leucocephala*. It is available all year round and the leaves can be collected at little or no cost. A 56-day feeding trial was conducted to evaluate the growth performance of *Heterobranchus longifilis* juveniles fed different dietary levels of *Leucaena* leaf meal to replace soyabean. A completely randomized design with three replicates was employed with five diets containing 0%, 10%, 20%, 30% and 40% *Leucaena* leaf meal (SWC, SW10, SW20, SW30 and SW40) was formulated. A total number of 150 *Heterobranchus longifilis* juveniles (22.33-28.6g) was used for the experiment. SW30 had the highest mean weight gain (MWG) of 25.47g±6.08 and SWC the lowest which was 12.47g±2.77. There was significant difference between SWC and other treatments ($P \leq 0.05$) for MWG. The specific growth rate (SGR) and PER followed the same pattern and also showed significant difference. The findings indicate that *Leucaena* leafmeal can partially replace soyabean meal at 30% inclusion level without any negative effects on the growth in the diet of *H. longifilis* juveniles.

Keywords: *Heterobranchus longifilis*, soyabean, *Leucaena* leaf meal, growth performance

INTRODUCTION

As global population continues to grow there is an increased demand for fish and other aquatic products (FAO, 2014). Aquaculture production remains the best option to meet this growing demand (WorldFish, 2018). The rapid expansion of the Aquaculture sub-sector will depend on the availability of affordable good quality feeds (Madu *et al.*, 2003). The use of plant protein sources such as soya beans and groundnut in fish diet may not be sustainable because they are good sources of protein for human beings and are expensive. Therefore, there is an urgent need to identify other protein rich plant resources that could supplement conventional protein feed ingredients (Sotolu and Faturoti, 2008).

Leucaena leucocephala belongs to the family *Fabaceae*, sub-family *Mimosoidae*. *Leucaena leucocephala* is one of the tropical legumes that have the potential of being used as a plant protein source (Amisah *et al.*, 2009). *L. leucocephala* is a fast growing evergreen multipurpose legume which is abundant in Nigeria, available all year round and the leaves can be collected at little or no cost (Heuze and Tranc, 2012). *Leucaena* leaf has crude protein values ranging from 15.2-34.3% dry matter (Monoj and Bandyopadhyay, 2007). Various authors have worked on replacing conventional protein feed ingredients such as soyabeans and groundnut cake (Aliu and Osaro, 2018; Jibrin *et al.*, 2018; Ibiyo *et al.*, 2020; Fakolade *et al.*, 2021). The aim of this study is to evaluate the growth performance of *Heterobranchus longifilis* juveniles fed different dietary levels of *Leucaena* leaf meal.

MATERIALS AND METHODS

The experiment was conducted in the Fisheries Unit of the National Open University of Nigeria, Kaduna. This place is situated in Igabi, Kaduna, Nigeria, its geographical coordinates are 10° 37' 57" North, 7° 28' 22" East and its original name (with diacritics) is Rigacikun.

Collection and Processing of *Leucaena leucocephala* Leaves

Leucaena leaves were collected from trees planted at the forage section of the College of Agriculture and Animal Science, Mando road, Kaduna, Nigeria. The leaves were handpicked and leaflets were separated from the long leaf stalk. About 500g of the leaf sample was soaked in ten litres of water at room temperature (30° C) for 72 hours. The leaves were removed from the water and allowed to dry homogenously in the sun until they became crispy (Amisah *et al.*, 2009). The leaf sample was ground into fine powder using a hammer

mill and packed into a polythene bag pending proximate analysis. All analysis was done in triplicates as described by AOAC (1990).

Formulation of Experimental Diets

Imported Danish Fishmeal (72% crude-protein), vitamin premix, groundnut cake maize, soyabean cake and bonemeal were purchased from a reputable feed miller in Kaduna. Each feed ingredient was weighed according to the formulation (Pearson's square method) and grounded into fine powder to improve pellet quality using a hammer mill. The feed ingredients were mixed together and then pelleted into 3mm using a locally fabricated industrial pelleting machine according to methods described by Gabriel *et al.* (2007) then the pellets were sundried. Five experimental diets containing 0, 10%, 20%, 30% and 40% *Leucaena* leaf meal were formulated. The diet with 0% *Leucaena* leaf meal served as control so was coded SWC while 10%, 20%, 30% and 40% inclusion levels of *Leucaena* leaf meal were coded SW10, SW20, SW30 and SW40 respectively. The gross composition of experimental diets is shown in Table 1 while the proximate composition of *Leucaena* leaf meal is shown in Table 2.

Table 1 Gross Composition of Experimental Diets

Ingredients (g/100g)	SWC	SW10	SW20	SW30	SW40
Fishmeal	30	30	30	30	30
Maize	20	20	20	20	20
Groundnut cake	10	10	10	10	10
Soyabean cake	38	34.2	30.4	26.6	22.8
<i>Leucaena</i> leaf meal	-	3.8	7.6	11.4	15.2
Bonemeal	1	1	1	1	1
Lysine	0.5	0.5	0.5	0.5	0.5
Methionine	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100

Calculated

Crude protein	45.00	44.2	43.3	42.6	41.7

Table 2 Proximate Composition of *Leucaena* leaf meal

Parameters	Percentage (%)
Moisture	8.15
Crude protein	22.08
Ether Extract	5.37
Crude fibre	21.5
Ash	4.56
Nitrogen free extract	38.33

Experimental Fish and Procedure

Three hundred juveniles of *Heterobranchus longifis* were purchased from Maidalla farms Mando and transported in 50 litres jerry-cans. The juveniles were acclimatized for 14 days and fed with commercial feed then starved for 24 hours prior to the commencement of the experiment. The juveniles were randomly sorted and stocked at 10 juvenile per tank. Feed not consumed and faeces were siphoned daily. At the end of the acclimatization period, 150 fishes were randomly selected, batched weighed and stocked into fifteen (15) 60-liter circular rubber tanks. Ten (10) fishes were stocked in each of the 60 litres tanks. The tanks were covered with net to prevent fish from jumping out. Water was supplied from a bore hole fitted with overhead plastic tanks. The water in the tank was changed twice a week. Left over feed and faeces were flushed out daily while any dead fish found was removed and recorded. Fishes were fed 2% body weight twice daily for 8 weeks. The ration was adjusted after every two weeks according to the weight increase recorded when the fishes were sampled.

Water quality parameters were taken every 2 weeks before sampling. Water temperature, Oxygen and pH was determined with a portable dissolved oxygen meter (TPB-607) and pH meter (pH-009) model

Growth Parameters

To determine the growth response of *H. longifis*, the following parameters were calculated as described by Castell and Tiews (1980).

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Mean Weight Gain (g) (MWG)

MWG = Wt2 - Wt1 1

Where Wt1 = initial mean weight of fish, Wt2 = final mean weight of fish

Protein Efficiency Ratio (PER)

PER = fish weight gain/ Protein intake (g) (g) 2

Where; Protein intake = % protein in feed x total diet consumed

Specific Growth Rate (SGR)

SGR = 100 (Log Wf – Log Wi)/ Time (days) 3

Wf = final mean weight at the end of the experiment; Wi = initial mean weight at the beginning of the experiment

Log = Natural Logarithm

Survival Rate (%) = Number of fish that survived/ number of fish stocked x 100.....4

Statistical Analysis

All data collected were subjected to one way analysis of variance (ANOVA) to test for significant difference among treatments using SPSS version 15.0 followed by Duncan's multiple range test (DMRT) which was used to separate significantly different means. The level of significance set for treatments was $P \leq 0.05$.

Results and Discussion

The growth parameters are presented in Table 3. The mean weight gain (MWG) was highest in treatment SW30 which had 25.47 ± 6.08 and lowest in SWC which recorded 12.47 ± 2.77 . There was significant difference ($P \leq 0.05$) between SWC and other treatments. The specific growth rate (SGR) and PER followed the same pattern and also showed significant difference ($P \leq 0.05$). The feed conversion ratio (FCR) was highest in the control and lowest in SW30 however there was no significant difference ($P > 0.05$) in all the treatments. The survival rate (SR) also showed no significant difference. The mean water quality parameters are presented in Table 4.

Table 3 Growth parameters of *Heterobranchus longifilis* fed graded levels of *Leucaena* leafmeal

Parameter	Treatment				
	SWC	SW 10	SW 20	SW 30	SW 40
IWT(g)	22.33 ^a	24.00 ^a	23.00 ^a	28.6 ^a	28.25 ^a
FWT(g)	34.80 $\pm$ 2.77 ^a	43.53 $\pm$ 3.07 ^{ab}	45.63 $\pm$ 2.30 ^{ab}	54.07 $\pm$ 6.08 ^b	50.41 $\pm$ 11.77 ^b
MWG(g)	12.47 $\pm$ 2.77 ^a	19.53 $\pm$ 3.07 ^{ab}	22.63 $\pm$ 2.30 ^{ab}	25.47 $\pm$ 6.08 ^b	22.16 $\pm$ 11.77 ^{ab}
SGR (%/day)	0.34 $\pm$ 0.06 ^a	0.47 $\pm$ 0.07 ^{ab}	0.53 $\pm$ 0.04 ^{ab}	0.55 $\pm$ 0.03 ^{ab}	0.44 $\pm$ 0.11 ^{ab}
FCR	2.37 $\pm$ 0.48 ^a	1.66 $\pm$ 0.14 ^a	1.46 $\pm$ 0.11 ^a	1.38 $\pm$ 0.26 ^a	2.25 $\pm$ 0.62 ^a
PER	0.95 $\pm$ 0.17 ^a	1.34 $\pm$ 0.14 ^{ab}	1.57 $\pm$ 0.11 ^{ab}	1.72 $\pm$ 0.26 ^{ab}	1.37 $\pm$ 0.69 ^b
SR (%)	100 $\pm$ 0.00 ^a	100 $\pm$ 0.00 ^a	100 $\pm$ 0.00 ^a	90.00 $\pm$ 10.00 ^a	93.00 $\pm$ 5.77 ^a

Means with same superscript within the same row were not significantly different ($P > 0.05$)

Table 4 Mean water quality parameters of the experimental tanks

Parameter	Treatments				
	SWC	SW 10	SW 20	SW 30	SW 40
DO (mg/l)	1.3 $\pm$ 1.1	0.5 $\pm$ 0.1	0.56 $\pm$ 1.5	0.56 $\pm$ 0.11	0.56 $\pm$ 0.11
pH	6.68 $\pm$ 0.72	7.33 $\pm$ 0.31	7.35 $\pm$ 0.35	6.95 $\pm$ 0.07	6.92 $\pm$ 0.42
Temperature	26.40 $\pm$ 1.85	24.30 $\pm$ 0.00	24.30 $\pm$ 0.00	24.66 $\pm$ 0.63	24.66 $\pm$ 0.63

The crude protein level in *Leucaena* leafmeal were similar to those reported by Amisah *et al.* (2009). The growth performance of *H. longifilis* fed graded levels of *Leucaena* leafmeal revealed that the diet formulated for growth trials met the crude protein requirement (40-42.5%) of *H. longifilis* as recommended by Eyo and olatunde (2001). All fishes fed actively on the experimental diets which demonstrate that *H. longifilis* was able to tolerate up to 40% inclusion level of *Leucaena* leafmeal and was able to utilize it for growth. The high mean weight gain of *Leucaena* leafmeal supplemented diets when compared to the control could be due to the effect of combining two or more biological compounds such as fishmeal, groundnut cake soyabean

cake and *Leucaena* leafmeal having a superior effect. Sogbesan and Ugwumba (2008) reported a similar effect when *H. longifilis* was fed with fishmeal, groundnut cake and termite meal. Furthermore, Amisah *et al.* (2009) reported increased weight gain of *Clarias gariepinus* with increase in inclusion levels of *Leucaena* leafmeal. This study is also in line with the work of Tiarniyu *et al.* (2015) who observed an increase in MWG as inclusion level of *Leucaena* leafmeal increased in the diet of *Clarias gariepinus* fingerlings. However, the highest inclusion level in the work was 20%. The findings of Fakolade *et al.* (2021) was contrary to this study, a decrease in MWG was observed as inclusion of *Leucaena* seedmeal increased in the diet of *Clarias gariepinus* fingerling. The water quality parameters were within the range recommended for catfish, this may be the reason for the high survival rate.

CONCLUSION

The implication of these findings is that *Leucaena* leafmeal can partially replace soyabean meal at 30% inclusion level without any negative effects on the growth in the diet of *H. longifilis*.

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APPRAISAL OF AQUACULTURE PRACTICES IN SELECTED FISH FARMS IN GOMBE

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ABSTRACT

The study was aimed at studying the aquaculture practices in selected fish farms in Gombe metropolis, Gombe state Nigeria. Objectives were to find out the species of fish cultured in the study area, to monitor the water quality and find out Constraints of aquaculture development in the study area. Fish sample were collected at three (3) fish farms for the period of three (3) months (April to June) 2021 and were identified using standard keys. Water quality was determined and compared with standard procedures. A questionnaire was designed to determine constraints of aquaculture which is divided into two sections. Section one contains elicited information on the personal characteristics of the respondents, while section two elicits responses to address constraints of aquaculture in the study area. Eighteen (18) fish farmers were randomly selected from the three (3) study area. Data obtained were analyzed using descriptive statistics and Analysis of Variance (ANOVA). Species of fish cultured is *Clarias gariepinus* and the water quality parameters studied shows the level obtained were within permissible limit. The findings revealed that majority of the fish farmers 88.89% were males and between the ages of 21-40 years. Majority of the farmers (22.22%) reported that high cost of feed is their major challenge; this is closely followed by poor marketing (22.22%), and poor finance (11.11%). Other constraints to fish production in the study area include: higher price of input (16.67%), inadequate supply of fish feed (11.11%), poor hatchery facilities (11.11%), and Disease (5.56%).

KEYWORDS: Aquaculture, appraisal, Gombe state, selected fish farms

INTRODUCTION

Aquaculture is defined as fish farming. It is the art and science of controlled rearing of fish in ponds, farms and in some instances natural water bodies from hatchlings to matured size. Kumar, (2004). Unlike fish that grow in the wild water bodies, without human interference, in aquaculture, activities such as feeding, fertilization, stocking, reproduction and harvesting are controlled. It is an important source of food, income generation, employment and recreation for people around the world (Dauda, *et al.*, 2017). Fish farming is one of the vital sectors that are being explored as it is the best and cheapest source of animal protein for human consumption (Dauda *et al.*, 2017).

Fish in their natural environment are prone to attack by diseases, predators and other undesirable conditions such as pollutions and aquatic weeds infestation. Also, over the recent decades the natural water bodies such as rivers, swamps, streams, lakes and seas had been over exploited by fisher folks without any deliberate attempt for replacement of aquatic resources especially in the developing countries (Akinwale *et al.*, 2014). There are also great concerns by consumers about the health implications of fish from the open waters due to the current rate of environmental pollutions from industries since the industrial revolutions. It is therefore commendable the current attention given to the development and growth of aquaculture globally.

Fish farming has not been fully explored as a strategy to reduce poverty level despite its potential to improve livelihoods in the study area. Low productivity, prohibitive establishment cost, high farm-level losses and inefficient marketing often pose a problem. The result of the studies will provide information on aquaculture practices in Gombe metropolis.

MATERIALS AND METHOD

Sampling procedure

The study was conducted within Gombe metropolis. Three fish farms were selected for the study namely: Gombe bye-pass, Gombe commercial area and Borunde. Fish sample were collected at three (3) fish farms for the period of three (3) months (April to June) 2021. Fish samples were identified using standard keys of identification of fish by Olaosebikan and Raji (2013). Water quality was determined using APHA (American Public Health Association), (2017) procedures. A questionnaire was designed to determine constraints of aquaculture in the study area which is divided into two main sections. Section one elicits

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information on the personal profile of the respondents (Bio-data) while section two elicit responses to address the constraints of fish farming in the study area.

Analysis of the variance (ANOVA) was used to analyze data on water quality and descriptive analysis such as frequency and percentage were employed for the constraints of aquaculture practices in the study area.

RESULTS AND DISCUSSION

Table 1. Types/species of fingerlings cultured (n=18).

Species of fingerlings used	n	Percentage of respondent (%)
<i>Clarias gariepinus</i>	18	100

n=number of respondent.

Result of Physico-chemical parameters

Table 2. Showing mean values for Physico-chemical parameters for the month of April, May and June.

Parameter	Gombe Commercial Area			Bye-pass			Borunde		
pH	6.7	7.5	6.6	7.5	7.6	7.2	6.8	6.8	6.5
Temperature (°c)	31	31	30	31	31	30	30	31	31
Dissolved Oxygen (DO) (mg/l)	4.0	5.1	6.5	3.5	4.5	5.5	5.0	5.0	5.0
Alkalinity (mg/l)	220	60	120	150	40	90	120	50	212
Chlorine (mg/l)	56	30	24	36	24	35	48	52	27

Table 3. Bio-data of the respondent

Characteristic	Response	Percentage (%)
Age of respondent	21-30/31-40	38.89
Sex of respondents	Male	88.89
Marital status of respondents	Married	66.67
Farming experience (year)	11-15	50
Educational level	Tertiary	77.78
Primary occupation of respondents	Fulltime farming	38.89

Table 4. Constraints of Fish farming (n=18).

Constraints	Frequency	Percentage (%)
Inadequate supply of fish feed	2	11.11
Poor finance	2	11.11
Poor hatchery facilities	2	11.11
High cost of feed	4	22.22
High price of input	3	16.67
Disease	1	5.56
Poor marketing/Price	4	22.22
Total	18	100

Aquaculture has been successfully practiced in different holding structures, Akinwale *et al.* (2014). The choice of species to culture is very essential to the success of any aquaculture venture Ugwumba and Ugwumba, 2003. From the result of these studies, the common species cultured is *Clarias gariepinus*. This is in consonance with the work of Ele *et al.*, 2013 on economic analysis of fish farming in Calabar. The high premium placed on the culture of *Clarias species* could be attributed to its wide 'acceptability and tolerance

to wide environmental conditions. Also the demand is so high in the study areas due to its flesh quality. The water quality parameters studied shows that the level obtained were within permissible limit. WHO, (2004).

Majority of the fish farmers are within the age bracket of that 21-30 and 31-40 years. This implies that most of the farmers have the ability to practice fish farming, at this age bracket which is a productive one, as such there is hope for increase in fish production in the state. This observation is in agreement with Sadiq and Kolo, (2015) who reported high youth participation in fish farming in Minna, Niger State, Nigeria. A great number of the males were involved in fish farming, while a few females participated in Aquaculture meaning that the males dominate the aquaculture sector in the study area. This observation is in tandem with the report of Ideba *et al.*, (2013) who reported that fish farming is dominated by the male population in Cross River State, Nigeria. The marital status of the respondent in the study area indicates that majority were married and were single. This means married men are more interested in fish farming possibly because they have responsibilities. This is in agreement with Ibemere, (2014), who reported married people participated more in fish farming in River State, Nigeria.

Majority of the fish farmers had 11-15 years' experience in fish farming activities, this implies that most of the fish farmers in the study areas are experienced. All the respondents are learned and educated as majority attended secondary and tertiary education. This means that fish farming is a technical enterprise that requires learned farmers and since majority of the respondents are literate innovation can be easily adopted. This is in agreement with Ajana, 1995 with Ibemere, 2014 in their report for Ogun and River States of Nigeria respectively. The primary occupation of the respondents revealed that majority of the fish farmers in the study area were fish farmer/businessmen, the study also showed that the business of fish farming can be operated as a part- time business. This is agreement with Ifejika and Ayanda, 2005 who reported that fish farming is majorly practiced in Niger State, Nigeria on part time basis. Ideba *et al.*, 2013 reported that 79% of fish farmers in his study areas were full time fish farmers.

Majority of the farmers reported that high cost of feed is their major challenge; this is closely followed by poor marketing and poor finance. Other constraints to fish production in the study area include: Disease, inadequate supply of fish feed, higher price of input, and poor hatchery facilities. These findings showed that virtually all the factors evaluated impeded fish production in the study area. This is in agreement with Okonji and Osayi, 2016 who reported that the aquaculture sector in Edo State, Nigeria is still small scale and is currently confronted with the problems of high cost of feeds, inadequate funds and poor water supply. Sadiq and Kolo, 2015 also reported that paucity of capital and high costs of feeds were some of the major challenges faced by fish farmers in Minna, Niger State Nigeria.

CONCLUSION

The most common species cultured is *Clarias gariepinus*. The physico-chemical parameters studied shows that the level obtained are within permissible limit which is suitable for cultivation of *Clarias gariepinus* and hence for aquaculture. Fluctuating in physicochemical parameters existed but these does not impair the suitability of the ponds for fish production. The findings of this research established that the fish farming in Gombe State is still under developed considering the culture facilities used, reliance on imported feed, the non-existence of water quality management, total reliance on external sources for stocker fish, the extremely low average production per annum and in regular water supplies and storage facilities.

RECOMMENDATION

Other species of fish apart from *Clarias gariepinus* should be introduced in to aquaculture in the study area. Continuous monitoring of water quality parameters is advocated, as these would provide information on preventing fish kill, producing larger and healthier fish for human consumption and for making a good profit.

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AQUACULTURE AND BIOSECURITY: THE CASE OF FISH FARMING IN DELTA STATE

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ABSTRACT

A study was carried out to assess the biosecurity risks, hazard and control measure on aquaculture production in selected fish farms around Delta State. Data was collected using a structured questionnaire administered to one hundred (100) fish farmers in the three senatorial districts in the state; and analyzed using descriptive statistics. The respondents were able to identify the presence of pathogens in their farms, whose sources could not be explained. 56.5% of the respondents reported that they recorded fungi infections in their farms, while 10.9%, 21.7% and 10.9% of the respondents recorded nematodes, viruses and others respectively. Delta North senatorial District had the least issue with pathogens, and suitability of water quality (8%) but had the highest fingerlings mortality (37%) than Central and South Senatorial Districts which were 49%; 33%; and 44%; 30% respectively. There is need to create awareness on best available/adoptable biosecurity measures that can be put in place in fish farms around to reduce the cases of introduced pathogens and their resultant effects on fish production, as well as, carry out risk analysis to ascertain the highest risks and how they can be managed/mitigated.

Keyword: Pathogens, biosecurity, aquaculture, fish farmers.

INTRODUCTION

Aquaculture is at a global average growth rate of 8.8%; 47% of fish consumed globally comes from aquaculture and an increasing risk of significant aquatic animal diseases emerging and spreading (Ernst *et al.*, 2017 and Wang *et al.*, 2019). There are aquatic invasive species (AIS) such as, parasites and disease outbreaks which are the major challenges in fish farming (Yee, 2019). The prevention, control, and eradication of infectious diseases in aquaculture also help in the prevention of human infection, animal infection, and environmental health issues that could arise from their risk (Lee and O'Bryen, 2003). Pathogens and diseases common in fishes are viral haemorrhagic septicaemia virus (VHSV), infectious haematopoietic necrosis virus (IHNV), ichthyophthiriasis (white spot disease), amongst others. Some of these pathogenic diseases show antibiotic resistance in (AMR) to drugs in health management (FAO, 2020). Studies on the characterization of antibiotic resistant bacteria in some ponds and rivers have been carried out (Abu and Wondikom, 2018; Ogbonna and Inana, 2018). Aside transmission of pathogens from fish-preying birds, amphibians and mammals (including man), fishes could transmit infection amongst themselves by horizontal transmission via mucus, fins or gills or vertical transmission when transmission is from the eggs of female fishes, or even oral transmission via consumption of infected feeds, infected waste water, equipment, poor water quality, etc. (Ernst *et al.*, 2017). Many factors influences the abundance and impacts of diseases in farmed fishes, they include; production management practices, biological and environmental factors (Adedeji and Okocha, 2011; Blancheton *et al.*, 2013; Musa *et al.*, 2013), which should be identified and prioritized. Many models and plans such as HACCP (Hazard, Analysis and Critical Control Point) have been developed to solve biosecurity risk (Bauman, 1990; Feng and Chen, 2018; Feng *et al.*, 2019; FAO, 2020). In recent times, there have been reports of high mortality especially in young fish larva within one week of hatching. Necessitating this study, to identify biosecurity risks in fish farms in the three senatorial districts of Delta State and proffer solutions to this challenge amongst others. Hence, primary data were obtained from selected fish farmers by the administration of structured questionnaire as the tool for assessment in this regard.

MATERIALS AND METHOD

Delta State was delineated into the Senatorial districts: North, Central and South; and structured questionnaire administered randomly to one hundred (100) identified fish farmers in the State sourced from the Department of Fisheries in the State Ministry of Agriculture and Natural Resources; which formed the sample population. The questionnaire were successfully retrieved from ninety respondents (which gave a sample size of N=90) from which primary data was generated and analyzed using descriptive statistics of frequency counts and percentages.

RESULTS AND DISCUSSION

Socio-Economic Characteristics

The demographic characteristics of the respondents (fish farmers) in the study area (Table 1); indicated that, male dominated (93.3%) in the business of fish farming in the State compared with the meager 6.7% female representation. This was indicative of a male dominated endeavor. The age groups of 21-35years (38.9%) and 36-45 years (34.4%) made a total of 73.3% of the sampled respondents which suggested that, most of the respondents were within the active age bracket, indicating productive use of time, energy and zest.

Table 1: Demographic Characteristics

Variable	Categories	Frequency of Occurrence	Percentage (%)
Sex	Male	84	93.3
	Female	6	6.7
Age	10-20year	1	1.1
	21-35years	35	38.9
	36-45years	31	34.4
	45years above	23	25.6
Education	No formal Education	4	4.7
	Primary Education	16	18.6
	Secondary Education	21	24.4
	Tertiary Education	43	50.0
	Vocational training	2	2.3

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Household Size	1-2	11	13.4
	3-6	45	54.9
	Above	26	31.7
	None	1	1.4
Number of income earners	1-2	48	67.6
	3-6	18	25.4
	Above	4	5.6
Type of Ownership	Personal	57	64.0
	Joint	13	14.6
	Company	3	3.4
	Rented	15	16.9
	Others	1	1.1
Membership of any Cooperative	Yes	38	42.7
	No	51	57.3
Years of Experience	1-5years	30	33.3
	6-10years	36	40.0
	11-20years	16	17.8
	21years above	8	8.9
Membership of Professional Fisheries Organization	Yes	18	21.7
	No	65	78.3

Sources of Broodstock used in Fish Breeding

The sources of fish broodstock used by the fish farmers in breeding reflect in the viability of fish seeds cultured. The question of sources of broodstock (Table 2) showed that, 39.0% of the total respondents bought their broodstock, 26.8% produced their broodstock from previously stocked seeds (grow-out), 1.2% got their broodstock from the wild, 9.8% received their broodstock as gifts while 4.9% purchased and sometimes produced their broodstock, 11.0% bought or obtained broodstock from the wild and 6.1% bought, produced as well as sourced broodstock from the wild. Equipment used on the farm by the fish farmers are either bought (62.8%) or borrowed (37.2%).

Table 2: Sources of Broodstock used in Fish Breeding

Categories	Frequency Occurrence	of Percentage (%)
Source of Broodstock		
Only purchase of broodstock	32	39.0
Only procure broodstock from wild	1	1.2
Produce broodstock	22	26.8
Others	1	1.2
Source of Equipment		
Borrow equipment	29	37.2
Do not borrow equipment	49	62.8

Sources of water and water management practices by fish farmers in Delta State

The sources of water of the respondents and the frequency at which they change the water used in the culture system were also factored in. To ascertain management practices engaged in, that could contribute to the biosecurity challenges experienced by the fish farmers. The data for the water sources of the respondents showed that, 3.7% sourced water from wells, 68.3% from borehole, 26.8% from streams/rivers while 1.2% sourced water from means not mentioned. These implied that, the water source was predominantly from borehole (ground water) which has been established as not suitable for fish breeding in this area (Egun and Oboh, 2017) due to the low pH. This portends a major challenge for the fish farmers besides the source(s)/quality of the fish seeds and feeds. And can be reflected in the fish production and performance/productivity of the farmers. Also, the management practices of the fish farmers especially water management (how frequently water in the culture systems were changed) showed that, 30.4% changed water daily, 35.4% changed water within a month (under a month), bi-monthly interval change was carried out by

3.8% while 30.4% changed water in 3months interval/during harvest period; indicting water management as another source/cause of fish mortality which will reflect in the outcome.

Table 3: Water Sources

Categories	Frequency of Occurrence	Percentage (%)
Sources of Water		
Well water	3	3.7
Borehole	56	68.3
Stream/River water	22	26.8
Others	1	1.2
Period of changing water		
Daily	24	30.4
<1Month interval	28	35.4
2Months interval	3	3.8
3Months/harvest period	24	30.4

Culture Practice in Senatorial Districts

The culture systems (Figure 1) favored by the respondents were determined based on the Senatorial Districts, a reflection of choice based on location, terrain and level of available technology/know-how. Delta south which has the highest number of fish farmers showed that, about 33.33% of the respondents had earthen ponds while about 25.6% had concrete ponds.

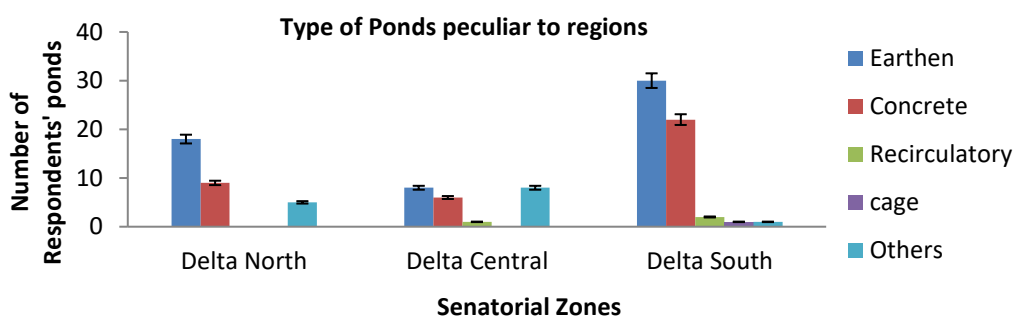


Figure1: Pond Facilities Peculiar to the Senatorial Districts

Challenges of Fish Farmers by Senatorial Districts

Based on the challenges experienced by the respondents according to Senatorial Districts, poor and expensive feed were documented highest in Delta North with a value of 52%. Delta Central had the highest broodstock mortality of 51% while Delta South had the highest fry mortality of 42 %. Generally, fry mortality, fingerling mortality, poor water quality and poor/expensive feeds were the challenges of all respondents across the Senatorial Districts (Figure 2). These can be prevented or curbed by training these fish farmers on available technologies and information dissemination on the best available practices.

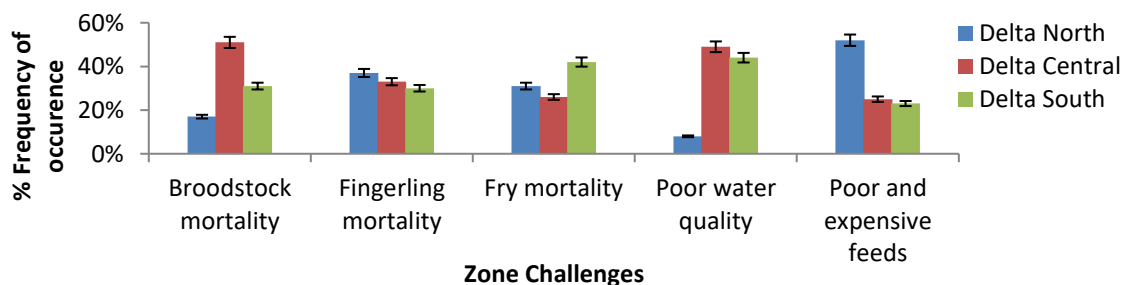


Figure 2: Frequency (%) Distribution of Challenges Experienced by Respondents and Occurrence by Senatorial Districts

Bio-security Risk Identification/Assessment

An assessment of the bio-security risks in the farms was done to determine the preventive modalities (hygiene practices, proper feed storage to prevent mold, observation of disease outbreaks, amongst others) put in place by the respondents in their farms to forestall avoidable eventualities (Table 4). The data showed

that; 37.7% have water-dip for visitors at the entrances of their facilities while 62.3% do not have water-dip for visitors; 63.2% of the facilities are clean and disinfected while 36.8% of the facilities are not clean and disinfected; 36.8% of the facilities are clean but not disinfected while 42.2% of the facilities are not clean and not disinfected. Indicating poor hygiene practices. For the storage of feeds, 36.4% of the fish farmers observe signs of mold and moisture on feed fed to fry while 63.6% do not observe signs of mold and moisture on feed fed to fry. On the other hand, 60.9% of the fish farmers observe that their stored fish feeds are free from mold and pests while 39.1% do not make such observations. For disease outbreak, 49.2% of the respondents have witnessed disease outbreak while 50.8% have not witnessed disease outbreak. 13.8% of the farmers responded that, their facilities are not maintained while 86.2% answered in the contrary. From the responses of the respondents, it can be adduced that, the practices of the farmers were not sufficient to prevent ‘bio-attack’ on fry/fingerlings/grow-out by opportunistic/invasive/disease-causing microorganisms/pathogens. Based on the risk of diseases entering into the farm (entry-level biosecurity), prevent health issues emerging/spreading within the farm (internal biosecurity), and reduce impacts/spread of diseases when they occur (exit-level biosecurity) (Ernst *et al.*, 2017). Farmers in Delta South (having the largest population of fish farmers) were also seen to experience the highest level of disease outbreaks (60.0%) compared to the other senatorial districts.

Table 4: Biosecurity Risk Assessment of Hatchery Facilities by Respondents

Category	Frequency of Occurrence	Percentage (%)
Have water dip for visitors	26	37.7
Facilities are Clean and disinfected	43	63.2
Facilities are not Clean and disinfected	25	36.8
Facilities Clean but not disinfected	27	42.2
Facilities are not clean and not disinfected	37	57.8
Facilities are not maintained	9	13.8
Experience multi usage of facility and no protocol	35	52.2
Experience signs of mold and moisture on feed fed to fry	24	36.4
Mold and pests on fish feed	25	39.1

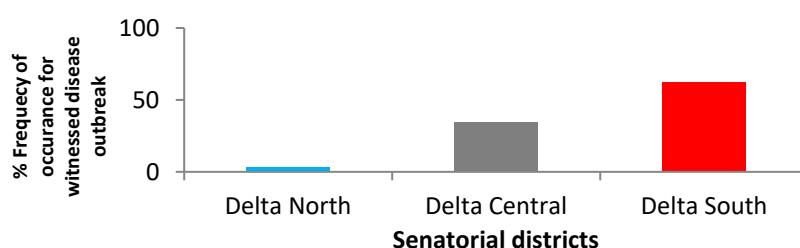


Figure 3: Frequency (%) Distribution of Disease Outbreaks Experienced by Respondents and Occurrence by Senatorial Districts

Table 5: Hazard (Diseases organisms) on Fishes in Respondents' Farms

Organism	Frequency of occurrence	Percentage (%)
Fungi	26	56.5
Nematodes	5	10.9
Viral	10	21.7
Others	5	10.9

In Table 5 above, 56.5% of respondents reported that, the fishes were more exposed to fungal infections, while 10.9%, 21.7% and 10.9% of the respondents recorded nematodes, viral and others respectively.

Critical control measures put in place by respondents for disease prevention

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With respect to the critical measures (for biosecurity) put in place by the respondents to prevent diseases (Table 6); 79.7% responded that, they have put preventive measures in place while 20.3% have not. Of the lot that have put measures in place; 45.2% attested to the use of antibiotics, 49.3% regular changing of water, 5.5% apply other measures not listed. For the water quality, 22.4% carry out laboratory analysis while 77.6% do not. The latter and former (regular changing water in systems of 49.3%) inferred poor water management practices. The use of antibiotics (45.2%) by the respondents and their undetermined effects on the target fish, as well as, man (the final consumer) implied inadequate measures in the facilities to prevent disease outbreak and also portend health risks, besides the possibility of antimicrobial resistance (AMR).

Table 6: Critical Control measures by Respondents

Category	Frequency of occurrence	Percentage (%)
Put preventive measures in place	55	79.7
Do not put any preventive measures in place	14	20.3
Use of antibiotics	33	45.2
Regular changing of water	36	49.3
Apply other measures	4	5.5
Carry out laboratory analysis	15	22.4
Do not carry laboratory analysis	52	77.6

The respondents, on their means of access to knowledge on fish farm operations and technology (Table 7C) showed that, 31.4% of the respondents' source knowledge from the internet, 7.0% from research works, 3.5% from extension agents, 41.9% from past experiences and 16.3% from friends. These implied that, a good number of the respondents may be working with obsolete information and technology, especially those who depend on past experiences and information from friends.

For the sources and updates of knowledge and information on fish farm operations and technology, the respondents gave varying media as means for these. Amongst which are: access to extension officers, access to internet facilities and social media platforms and attendance of Fisheries Conferences and Trainings.

For access to extension officers as source of knowledge and information on fish farm operations and technology (Table 7A), only 38.8% responded in the affirmative while 61.2% have no access to extension officers. Of the respondents with access to extension officers, 70.6% get this annually, 20.6% quarterly and 8.8% monthly. Information is an indispensable factor in agricultural practices and it is the basis of extension service delivery, especially when accurate, timely and relevant (Adereti *et al.*, 2006). With respect to using internet facilities and social media platforms as sources of knowledge and technology (Table 7B), 60.0% have and use the internet as source while 40.0% do not have access to or use internet facility. For those who use the internet, 9.9% have only whatsapp account, 22.2% have only facebook account 3.7% have only Twitter account while 35.8% have Facebook, WhatsApp, Twitter and Instagram accounts. 59.0% have an email account while 41.0% do not have an email account. These respondents can be said to be on communication platforms that can readily be accessed as platforms for information dissemination; thus making the farmers reachable with fish farm operations/technology updates and information. According to Mgbada (2006), access to adequate information is very essential to increased agricultural productivity.

30.2% of the respondents reported that, they attend Fisheries Conferences while 69.8% responded that, they do not attend such conferences (Table 7D). These responses revealed the need for extension services to be provided for these fish farmers; utilizing all available social media platforms for the dissemination of update information and technology. Also, the benefits of identifying with Fisheries bodies and attending such conferences for their benefits need to be emphasized to the farmers for inclusion.

Table 7: Sources of Information

A: Access to Extension Officers

Category	Frequency of occurrence	Percentage (%)
Access to extension officers	33	38.8
Extension officers come monthly	3	8.8
Extension officers come quarterly	7	20.6
Extension officers come yearly	24	70.6

B: Acquainted with Internet Facilities and Social Media Platforms

Category	Frequency of occurrence	Percentage (%)

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Internet acquaintance	51	60.0
Have only WhatsApp account	8	9.9
Have only Facebook account	18	22.2
Have only Twitter account	3	3.7
Have Facebook, WhatsApp, Twitter and Instagram	29	35.8
Have accounts in other social media platforms	4	4.9
None at all	19	23.5
Have an email account	49	59.0

C: Sources of Knowledge

Category	Frequency of occurrence	Percentage (%)
Source of knowledge to solutions from internet	27	31.4
Source of knowledge to solutions from research work	6	7.0
Source of knowledge to solutions from extension agents	3	3.5
Source of knowledge to solutions from past experience	36	41.9
Source of knowledge to solutions from friends	14	16.3

D: Attendance of Fisheries Conferences and Trainings

Category	Frequency of occurrence	Percentage (%)
Attend fishery conferences	26	30.2
Do not attend fishery conferences	60	69.8

CONCLUSION

From the responses of the respondents, it can be adduced that, the practices of the farmers were not sufficient to prevent 'bio-attack' on fishes by opportunistic/invasive/disease-causing microorganisms/pathogen indicative of poor biosecurity measure. The implementation of biosecurity measures would prevent/protect/mitigate stocks against prevailing, new and emerging diseases, as well as, protect human health. Depending on the farm size, type of fish culture and facility, the first steps to ensure the biosecurity of fishes/farms is to control contamination at the entry level (healthy broodstock/seeds, wearing clean clothes, boot, having footbath and hand disinfection at the farm entrances, hygienic and quality feeds, having a quarantine unit, etc.). It is highly recommended for every farm to have qualified staff to assure good water quality in the pond and a good health of the fish. All equipment should be kept clean, and disinfected. Extension services of institutions (private or public) should inform fish farmers on biosecurity and emphasize on the benefits a fish farmer stands to gain in identifying with Fisheries bodies and attending conferences.

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THE RESILIENCE OF AQUACULTURE FISHERY AND INCOME GENERATION IN THE POST-COVID ERA IN NIGERIA: REVIEW OF STUDIES

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ABSTRACT

The COVID-19 pandemic has had significant negative social and economic impacts on the global society. This study focuses on the resilience of aquaculture fishery and income generation in the post – COVID era in Nigeria. Since the confirmation of the first COVID-19 case in Nigeria, active cases and deaths have risen steadily while fragile economies were grappling with growth issues. The growth rate of Nigeria's GDP for 2020 was not only halted, but revised from 2.5% to 2% due to low Oil prices and limited fiscal space. The fishery supply chains are affected by the COVID-19 pandemic, causing jobs, incomes and food insecurity at risk. The study relied on secondary data obtained from economic and fisheries experts, and other relevant documents. The Multiple analyses results indicated that fishery was significantly affected over a period of time. The paper, suggests that for the economic growth of Nigeria to be repositioned, the agriculture (fisheries) should be reviewed and government intervention intensified.

KEYWORDS: Covid-19, income generation, resilience, aquaculture fishery

INTRODUCTION

One of the fastest-growing food-producing sectors is the aquaculture industry which accounts for approximately 50% of global fish production (Omeje *et al.*, 2020). Aquaculture provides nourishment, sustainable livelihood, food security, and poverty reduction to millions of people (Galappathi *et al.*, 2020). This has led to the realization of aquaculture as a potential to diversify farmer livelihood and income. The aquaculture production sector is extremely diverse but it nevertheless relies heavily on labour, inputs, financing and markets (Galappaththi *et al.*, 2020). Key activities in the aquaculture supply chain are fish production, processing, transport of inputs, distribution, wholesale and retail marketing. Each of these activities is of equal importance to the success of the supply chain. However, each stage of the chain is susceptible to being disrupted or stopped by impacts arising from various issues, including COVID-19. Although COVID-19 does not directly affect fish, however, it has an indirect impact on the aquaculture sector through various means (Grema *et al.*, 2020). In Nigeria, the aquaculture business is thriving again during the post covid era due to the resilience of all actors in the aquaculture value chain. Resilience in

aquaculture, therefore, implies having the capacity to deal with change, persist and continue to develop in ever-changing environments (sensu Folke, 2016). As opined by Kassam and Dorward (2017), aquaculture can have stronger backward and forward linkages and a larger multiplier effect on local economic growth and poverty reduction. However, there is little systematic evidence on the performance and dynamics of aquaculture in Nigeria after the covid era and how they can be strengthened to be drivers for food security, job creation, and resilient agri-food systems. Omega *et al* (2021) examined the effect of Covid-19 on Aquaculture in Oyo state, Nigeria and how fish farmers were able to prevail over the menace on their businesses. The questionnaire was made up of both open and close-ended questions. It focused on three parts, namely: The effects, challenges and measures to reduce the effects of COVID-19 on aquaculture.

Okuduwor *et al.* (2021) used multi-stage sampling techniques to collect primary data from four big and central markets in Port Harcourt (Borokiri, Creek Road, Mile one and Oil mill markets). The authors provided a comprehensive, systematic, and rigorous assessment of the sector and a synthesis of lessons learned, using a value chain approach and subsector analysis, and building on several years of work by the authors in the sector. Ragasa *et al* (2022) also collected field data through phone interviews, social media (WhatsApp, Facebook Messenger) interviews or any other means (on paper, and email), with reliance on distance and travel restrictions as done in previous studies (Arthur *et al.*, 2018).

RESULTS AND DISCUSSION

Table 1: Perception of Fish Farmers

Variables	Response(%)		
	Disagree	Neutral	Agree
Demand decline	2(18.2)	1(9.1)	8(72.7)
The high cost of production	1(9.1)	3(27.3)	7(63.6)
Fish is more expensive	2(18.2)	3(27.3)	6(54.5)
Improved marketing strategies	1(9.1)	7(63.6)	3(27.3)
Improved sales volume	7(63.6)	3(27.3)	1(9.1)
Increase feasibility in the market	4(36.4)	5(45.5)	2(18.2)
Reduction of manpower on the farm	1(9.1)	3(27.3)	7(63.6)

Source: Omega *et al* (2021)

Table 1 shows the perception of fish farmers on how COVID-19 affected them. The results indicated that there was a reduction of manpower engaged in farm work but an increase in market feasibility (Omega *et al.*, 2021). The finding is an indication that actors in aquaculture have resilience in the post COVID era to cope in terms of employment sustainability and medium of augmenting the sales of their product without physical contact as well as how to reduce the cost of production to attain maximum profit.

Table 2: Economic Implication of Covid-19 on Fish Farming

Factors	Low (%)	Moderate (%)	High (%)
Employment Opportunity	100	-	-
Food Security	42	58	-
Enterprise Development	100	-	-
Price of Fish	-	-	100
Foreign Exchange	100	-	-
Income Generation	70	30	-
Cost of Health Care Services	-	-	100

Source: Okuduwor *et al* (2021)

Results by Okuduwor *et al.* (2021), depicted in table 2 revealed the economic status of the indices used during the covid-19 lockdown and which can still be applicable at post covid dispensation. As divulged by

Okuduwor *et al.* (2021), the Covid-19 pandemic had low implications for employment opportunities and income generation. Again, 100% of the opinion of respondents examined by Okuduwor *et al.* (2021) said that the impact of the Covid-19 Pandemic on enterprise development/business expansion and foreign exchange was low while its impact on the cost of healthcare services and the price of fish was high. The food security recording 58% moderate and 42% low impact may be a result of local supply sources of some food items and the few exceptional ones brought in from nearby states as well as state government palliative measures on some food items in port Harcourt during the covid- 19 lockdown period. However, income generation was 70% low, indicating a drastic drop in the income levels of fish suppliers. Further, the findings of Okuduwor *et al.* (2021) showed the challenges faced by fish farmers during the period of the COVID-19 pandemic which included the reduction in walk-in customers to the farmers (4.50%), this was followed by the high cost of inputs (4.29%), inability to access raw materials (4.01%), inability to access the fish market because of the lockdown (3.98%), inability to access fingerlings (3.84%), inability to get technical support (3.73%) and the least challenge being employee's inability to come to work because of the lockdown (3.66%). A further probe into the results leads to the Wilcoxon sign rank test to find the relationship that exists between the variables and the significance of the relationship, which implies that aquaculture enterprise is resilient to covid-19 effects (as long as ideal enabling factors are available to its value chain actors). During the post-covid era, different adaptive measures are available to aquaculture businesses and one of the emerging adaptations observed globally has been to develop direct retail sales (Blank, 2020), through internet ordering and home delivery for aquaculture drive-in (France 3, 2020). Another adaptation has been to process and freeze fish that have reached their commercial size, to keep them in cold storage (AGRO, 2020). The market effects of the pandemic have brought about several far-reaching changes, many of which are likely to persist in the long term. Aggregate prices for 2020, as measured by the Fish Price Index (FAO, 2020), revealed that the importance of retail sales has significantly increased at the expense of food services, as the hospitality sector has remained subdued. Consumers, who are trying to limit frequent visits to grocery stores and are concerned about future lockdowns, have shifted their seafood preferences towards preserved and prepared products, while demand for fresh fish has waned.

As revealed by Omega *et al.* (2021), some coping strategies adopted to mitigate the effect of COVID-19 by fish farmers which is still relevant in the post Covid-19 era included the development of own feed (36.4%), this was followed by a reduction in borrowing rate (27.3%), assistance from the government and organizations (18.2%) while, the least adopted was the reduction in production activities and starving fish for days (9.1%). The results on the development of their feed are consistent with van Beijnen and Yan (2020), who reported that African fish farmers should focus on the production of their product (input) to reduce the cost of production. An FAO (2020) report in April 2020 emphasized the need for governments to support the aquaculture sector through subsidies and other relief services. Nigerian aquaculture sector, before the pandemic, was already faced with challenges such as the shortage of inputs (fingerlings and feed), lack of knowledge resulting in poor management practices, inadequate funding, use of poor quality seeds, high cost of feeds, low capital investment, etc. This implies that the COVID-19 pandemic was not the actual cause of challenges faced by farmers, but they are already exposed to these challenges (Senten *et al.*, 2020).

Even before the covid-19 pandemic and till now gender inequalities persist in aquaculture, where women represent half of the workforce when both the primary and secondary seafood sectors are considered (Care, 2020). FAO (2020) revealed that fish supply, consumption and trade revenues are all expected to decline due to the impact of containment restrictions on-demand, logistics, prices, labour and business planning. Global aquaculture production is now expected to fall for the first time in many years, by some 1.3 percent (FAO, 2020). However, it is appreciating gradually at the moment. Generally, fish are marketed fresh or smoked in Nigeria. Smoked fish is popular because of its special taste and because no cold storage is required. Therefore, Post covid era gives improvement to the patronage of smoked and dried fish.

In the return to business-as-usual scenarios, the public and private sectors will want to re-establish supply chains and access to markets, which may have been disrupted during the lockdown. Yet, they may also want to reduce the costs from possible future occurrences of similar outbreaks by correcting the vulnerability in the supply chain (for example not being dependent on one supplier and shortening supply chains). This could involve diversifying suppliers/processors to have more supply chain control and focusing on local or regional suppliers. While increased online retailing (e.g. digitization) has developed at a dramatic rate, especially in Asian markets and North America, the long-term trend toward e-commerce in household purchases of fish products may evolve (Cherry, 2020).

CONCLUSION

The global health crisis caused by COVID-19 has led to an unexpected effect on world economies with economies struggling to mitigate the effect of the pandemic and the Nigerian aquaculture sector is no exception to the difficulties caused by the effects of the crises. But post Covid-19 era has enabled farmers to develop their feed and take advantage of the government's interventions to reduce the impacts on their activities. In any case, aquaculture in Nigeria will continue to provide income and employment opportunities, especially in the post Covid-19 era.

Policy Recommendations

For competitiveness and resilience, the sector needs improved seed and management practices and lower-cost quality feeds through policies and stakeholders' cooperation.

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EFFICACY OF *RAUWOLFIA VOMITORIA* ROOT EXTRACTS AS ANAESTHETIC AGENTS IN AFRICAN CATFISH (*CLARIAS GARIEPINUS*)

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ABSTRACT

The efficacy of *Rauwolfia vomitoria* root extracts as anaesthetic agent in juveniles and adult sizes of *Claria gariepinus* were investigated. The time of induction (time taken for the fish to get anaesthetized) and recovery (time taken for the fish to recover from the effects of the anaesthetics) for various concentrations were recorded in seconds using a stop watch. The concentrations used for the anaesthesia bioassay were: 0.00-control, 50.00, 100.00, 150.00, and 200mg/l. The results obtained indicated that the induction time in both sizes were found to decrease significantly ($P < 0.05$) as the concentrations of the *R. vomitoria* root extracts increased, with the shortest induction time 145.00 ± 3.00 (s) observed in juveniles at the concentration of 200mg/L and the longest 266.66 ± 12.12 (s) in adult at the concentration of 50mg/L of the extracts. However, the recovery time increased significantly with increasing concentration of the *R. vomitoria* root extracts, with the highest recovery time of 732.33 ± 11.50 (s) observed in Adult size, at 200.00mg/L concentration and the lowest 434.33 ± 28.29 (s) in Juveniles at 50.00mg/L concentration of the extracts, with the optimum dosage of 50.00mg/L and 100.0mg/L for juvenile and Adult sizes respectively. Interestingly, the survival of the exposed fish during the trial was 100% in both sizes, as no mortality was recorded in all concentrations of the plant extracts. The findings of this trial, indicated that *R. vomitoria* root extracts, was efficient with zero mortalities and therefore can be recommended as an effective anaesthetic for use in aquaculture.

Keywords: Anaesthetics, Aquaculture, Plant extracts, Catfish, Stress

Introduction

Increased concern about animal welfare and potential pain caused culture fish species during routine manipulations has identified the search for ideal and appropriate anaesthetics for use in aquaculture (Southgate, 2008). The use of anaesthetic enhance safety for both the fish and the handler during aquaculture operation and allows them to be performed out of the water with minimal stress for the fish (Mylonass *et al.*, 2005). Anaesthesia minimizes pain in fish and induces a calming effect followed by loss of equilibrium, mobility and consciousness (Summerfelt and Smith 1990; Akinrotimi *et al.*, 2011a). Anaesthetics in fish farms are used to minimize mortality during handling and transport. This may reduce susceptibility to pathogens and infection (Wood *et al.* 2008). Anaesthetics are also used in fish during artificial spawning, weighing, tagging, grading, blood sampling, surgery and surgical procedures (Avilez *et al.*, 2004). When choosing an anaesthetics, a number of considerations are important, such as efficacy, cost, availability and ease of use, as well as toxicity to fish, humans and the environment and the choice may also depend on the nature of the experiment and species of fish (Akinrotimi *et al.*, 2011b). Knowledge about the ideal and optimum concentration of an anaesthetic for various fish species is necessary because in-appropriate concentrations may lead to adverse effects on the fish.

One of the prominent plant that has anaesthetic property is *Rauwolfia vomitoria*, commonly called devil sizzle stick, belonging to the family *Apocynaceae*, is a rain forest shrub that grows in Nigeria having oval leaves with straight venation and cluster of tiny flowers (Akpanabiatu *et al.*, 2009). It is widely distributed in West and East Africa. The members of this family usually have medicinal properties. The root bark extracts are reportedly being used in various ways in many African countries, for example, in Nigeria, it is used by traditional healers in treating psychiatric patient. While in the Democratic Republic of Congo it used to treat leprosy. In Ghana it is used to treat athrithis (Opajobi *et al.*, 2011). The barks has purgative, sedative and emetic properties and the major physiochemical constituents of this plant include alkaloids, glycosides, polyphenols and reducing sugar (Eteng *et al.*, 2009). The alkaloids have been reported to include reserpine, a well-known antihypertensive substance found in this plant (Amole and Onabanjo, 2004). Usages of *R. vomitoria* in fish anaesthetic is very limited. Hence, this study therefore assessed the efficacy of *R. vomitoria* root extracts as anaesthetics agents in two sizes of *C.gariepinus*.

Materials and Methods

Project Location and Sources of Experimental Fish

This study was carried out at the Genetic family testing unit hatchery of African Regional Aquaculture Centre (ARAC) Aluu, Port Harcourt. A total of four hundred and eighty (480) apparently healthy *C. gariepinus* which consists of 240 each of juvenile (mean length 26.64cm $\pm$ 3.11SD and mean weight 356.21 $\pm$ 12.91SD) and adult (mean length 52.13 $\pm$ 12.91 and mean weight 1100.38g $\pm$ 41.61SD) were sampled from ARAC rearing concrete tanks adjacent to the experimental site. These tanks are being stocked for at least two production cycles annually. The juveniles were of the age (12 weeks) and the adult (24 weeks). The fish were harvested from the tanks after draining, using drag net. They were immediately transferred into holding tanks at the experimental site.

Fish Acclimation

In the hatchery, the fish were acclimated to laboratory conditions for a period of three days. In four 100litres rectangular tanks. (Gabriel *et al.*, 2004). During this period the fish were fed daily at 0.5% body weight and the water in the holding tanks were renewed daily.

Source of Anaesthetics Agents

Rauwolfia Vomitoria

R. Vomitoria roots were obtained from a forest near senior staff quarters in Rivers State University of Science and Technology, Port Harcourt. Forest experts from the Department of Forestry of the same University authenticated a sample of plant and confirm it to be the roots of *R. vomitoria*. The roots were cleaned with clean water, in bowl, and made free from sand. They were later cut into pieces and dried in the laboratory. The fresh air-dried roots were macerated into smaller pieces using a kitchen blender (Model, H112, Plenwood, Japan). After this 5kg was weighed and soaked in 5 litres of water for 24 hours for the extract of the plant following the method of Peri *et al.* (1991).

Preparation of Test Solution

A stock solution of the anaesthetic was prepared by adding 1ml of the anaesthetic concentrate to 1 litre of water. Exposure concentration of anaesthetics were 0.00ml/L (control); 50, 100, 150, and 200ml/L. Thirty 50L plastic containers were labeled each filled with water from borehole to the 30L mark, and another 30 tanks filled with fresh water without anaesthetics were placed side by side. The different concentrations were prepared by serial dilution by measuring 50ml, 100ml, 150ml and 200ml of the stock solutions (x30) that was made into 30L with the borehole water that gave the desired concentrations.

Experimental Procedure

The mixture of anaesthetics with water given the desired concentrations was then stirred with a glass rod of 50cm in length for homogeneous mixture. Within 10 minutes the tanks were randomly stocked with 10 juveniles per tank, while 4 were stocked for adult fish using a scrop net. The tanks were not aerated during the experimental period.

Determination of Induction and Recovery Time

The time for onset of anaesthesia for the exposed fish was measured using a digital stopwatch. Fish behaviour was monitored individually through the induction and life recovery stages in each life stage and concentrations for all the eight anaesthetics. In the induction stage, five different behaviours were observed (Coyle *et al.*, 2004) slow swimming, slight increase in opercula beat frequency, lost of equilibrium, loss of reflexes and movement and lastly deep anaesthesia, where the fish was lying on one side and lay at the bottom of the tanks. After the anaesthesia, fish was removed individually using a scoop net and transferred into a clean water tank. Recovery time which followed the following stages; reappearance of opercula movements, partial recovery of equilibrium, irregular balance, Total recovery of equilibrium and lastly, normal swimming were observed. Recovery time was then recorded.

Survival of Exposed Fish

After the recovery stage in clean water, the exposed fish were monitored for any mortality. This was done by physical observation and any mortality was recorded. The percentage survival was calculated using the formula

$$\frac{\text{No of survival fish}}{\text{Total No. of fish exposed}} \times \frac{100}{1}$$

Source: FAO (2000).

Evaluation of Water Quality Parameters

Water quality parameters: dissolved oxygen, nitrite, ammonia and sulphide were evaluated using LaMotte fresh water test kit (Model AQ4, Chestown, Maryland, USA). pH and DO were determined with pH/DO meter (Model, H 9812, Hannah Products, Portugal).

Statistical Analysis

The data obtained from the study were collected and analyzed using statistics software 8.0 for windows/Data were first tested for normality (Kolmogorov - Smirnov test) and homoscedasticity of variance (Barlett's test). When these conditions were satisfied, a one way analysis of variance (ANOVA) was employed to reveal significant differences in measured variables among control and experimental groups. When a difference was detected ($P < 0.05$), Tukey's multiple comparison test was applied to identify which treatment were significantly different

Results and Discussion: The water quality parameters in *Rauwolfia vomitoria* root extracts experimental tanks were shown in Table 1. Significant variations ($P < 0.05$) comparable to control with 200mL^{-1} were noticed in pH (6.92 ± 0.13 to 9.20 ± 0.18) and sulphide (0.04 ± 0.01 to 1.96 ± 0.12) while other parameters evaluated were within the same range with no significant difference ($p > 0.05$). The induction time recorded in both sizes of *C. gariepinus* exposed to *Rauwolfia vomitoria* root extracts were within the same range, as low values were observed at different concentrations (table 4.16). Also, the recovery time, which tends to

increase corresponding with the increase in concentrations of the root extracts, were observed to be in the same range for both juveniles and adult sizes, with same value of 350.00(5) recorded at 200m/L⁻¹) (Table 4.16). The survival rates were 100. 00% in both sizes.

Table 1: Water Quality Parameters in Experimental Tanks of *C. gariepinus* exposed to *Rauwolfia vomitoria* root Extracts (Mean ± SD)

Parameter	Concentrations (mgL ⁻¹)				
	0.00	50.00	100.00	150.00	200.00
Temperature (°C)	28.96± 0.30 ^a	28.96± 0.41 ^a	28.86 ± 0.21 ^a	29.00± 0.53 ^a	29.20± 0.72 ^a
pH	6.92± 0.13 ^a	7.50± 0.10 ^{ab}	7.90± 0.17 ^{ab}	8.56± 0.42 ^b	9.20±0.18 ^c
Dissolved Oxygen (mgL ⁻¹)	6. 04± 0.31 ^b	6.07±0.34 ^b	6.13± 6.41 ^{ab}	6.10± 0.12 ^{ab}	6.18± 0.41 ^a
Nitrite (mgL ⁻¹)	0.06± 0.13 ^a	0.05± 0.02 ^a	0.06± 0.02 ^a	0.06± 0.11 ^a	0.06±0.01 ^a
Ammonia (mgL ⁻¹)	0.34± 0.05 ^a	0.34± 0.05 ^a	0.34± 0.04 ^a	0.32± 0.02 ^a	0.33± 0.04 ^a
Sulphide (mgL ⁻¹)	0.05± 0.05 ^a	0.05± 0.01 ^a	0.06± 0.01 ^a	0.09± 0.02 ^{ab}	0.09±0.02 ^{ab}

Mean within the row with different superscripts are significant (P<0.05)

Table 2: Induction, Recovery and Survival *C. gariepinus* exposed to *Rauwolfia vomitoria* Root Extracts(Mean ± SD)

Life Stage	Parameter	Concentrations (mgL ⁻¹)				
		0.00	50.00	100.00	150.00	200.00
Juvenile	Induction time (s)	0.00± 0.00	180.0±7.93	168.33±1.52	150.66±3.052	145.00± 3.60
	Recovery time (s)	0.00± 0.00	434.33± 28.29	584.32±8.50	596.14± 49.21	604.0±15.390
	Survival (%)	100.0± 0.00	100.00±0.01	100.00± 0.00	100.00± 0.01	100.00±0.01
Adult	Induction time (s)	0.00± 0.00	206.66± 12.12	156.33±36.50	126.66±1.52	119.00±1.00
	Recovery time(s)	0.00± 0.00	581.0±12.61	616.00±21.63	700.33± 15.4	732.33± 11.503
	Survival (%)	100.0± 0.00	100.00± 0.01	100.00±0.01	100.00± 0.01	100.00±0.01

Mean within the row with different superscripts are significant (P<0.05)

he water quality parameter of the various test media did not vary significantly (P<0.05) from those of the control. Since the parameters examined were within acceptable ranges for fish culture and toxicity test (Velisek et al., 2007). They may not have acted synergistically with the anaesthesia to affect the behavior observed during the research. The result from this study compares favourably with those conducted to compare the efficacy of commonly used anaesthetics on various fishes (Akinrotimi et al., 2013a). *The present study revealed that R. vomitoria* root extracts acted as an anaesthetic agent in sedating both sizes of *C.gariepinus* at different concentrations. It acted by widespread depression of the central nervous system produced by an action on nerve axons, transmitter release or membrane excitability (Barton, 2000; Akinrotimi et al., 2014a). Ross & Ross (1999) reported that anaesthesia is achieved by placing the fish into an anaesthetic solution that is absorbed through the gills and enter the arterial blood to the central nervous system. Anaesthetics are needed for easy handling, sorting, measuring, transporting and surgical procedures in aquaculture and fisheries to facilitate application procedure. The induction time recorded in this work, reduced as the dosage of *R. vomitoria* root extracts increased, while the recovery of anaesthetized fish increased notably with increasing concentrations of the extracts. This observation agrees with the findings of Akinrotimi et al (2013b) in two species of mullets exposed to clove seed extracts. This trend followed the

pattern of typical fish anaesthetics (Mylonas *et al.*, 2005). In terms of induction and recovery time to anaesthetic, the aqueous extracts of *R. vomitoria* root met Marking and Meyer (1985) criterion for ideal anaesthetics suitable for application in teleost fish. *Generally, an ideal anaesthetic ought to induce anesthesia quickly in less than 6min, permit a fast recovery in 10min or less, not poisonous to fish, nor hazardous to human, available and must be inexpensive* (Marking and Meyer, 1985). With the optimum dosage of 100.00mg/L and 150.00mg/L for juveniles and adults sizes respectively, *R. vomitoria* root extracts to meet many of the criteria used in evaluation of an ideal anaesthetic and compared favourably with conventional anaesthetics like MS-222, metomidate and 2-phenoxyethanol. Its main advantage lies in its availability all the year round, low cost, easy to use and high safety margins to humans (Opajobi *et al.*, 2011).

Conversely, earlier reports indicate that size does not have a direct influence on the time required to induce anaesthesia in fish (Ortuno *et al.*, 2002; Kucuk, 2010). However, a considerable variation exists within sizes of the same species in response to anaesthetics application, in aquaculture (Daziaman *et al.*, 2005). Variations in anaesthetic response in two sizes of yellow perch (*Perca flavescens*) exposed to MS-222, eugenol and 2-phenoxyethanol were observed (Feng *et al.*, 2011). The induction times were higher in the bigger fish, compared to the smaller ones. Also, increased efficacy and sensitivity with increasing body size have been observed in Atlantic salmon, (*Salmo salar*) and in goldfish, (*Carassius auratus*) anaesthetised with metomidate (Fichi *et al.*, 2007). Moreover, larger (60g) of white sea bream, (*Diplodus sargus*) took a longer time to anaesthetize than smaller (30g) fish when exposed to 2-phenoxy ethanol (Hajek *et al.*, 2006). Furthermore, the same trend was reported in Nile tilapia (*Oreochromis niloticus*) exposed to Sodium bicarbonate (Opuyo *et al.*, 2013). In the present study, the sedation and anaesthesia induction times were higher in adult size of *C. gariepinus* exposed to *R. vomitoria* root extracts as anaesthetics than in juveniles. This may be due to the fact that larger fish have a small gill surface area in relation to body weight and consequently a small area for anaesthetics diffusion (Akinrotimi *et al.*, 2014b).

CONCLUSION

The results in this study concluded that applications of *R. vomitoria* root extracts as anaesthetics did not affect the water quality parameters. Though, *R. vomitoria* root extracts acted as an anaesthetic agent in sedating three sizes of *C. gariepinus*. The induction time recorded in this work, reduced as the dosage of *R. vomitoria* root extracts increased, while the recovery of anaesthetized fish increased notably with increasing concentrations of the extracts. This trend followed the pattern of typical fish anaesthetics. In terms of induction time and recovery time to anaesthetic, the aqueous extracts of *R. vomitoria* root extracts met the criterion which for an ideal anaesthetics. An effective concentration of 100.00mg/L and 150.00mg/l of *R. vomitoria* root extracts could be used to sedate juveniles and adult sizes respectively.

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ECONOMIC ANALYSIS OF REPLACING SOYBEAN MEAL WITH FERMENTED *S. OBTUSIFOLIA* SEED MEAL IN THE DIETS OF *CLARIAS GARIEPINUS*

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ABSTRACT

This study investigates the economic viability of replacing soya bean with graded levels of fermented *Senna obtusifolia* (linn) seed meal in the diets of *Clarias gariepinus*. Five isonitrogenous (42% crude protein) and isocaloric (25.7% NFE) diets were formulated in which fermented (SOSM) replaced Soybean meal (SBM) at 0% (SOSM0), 25% (SOSM25), 50% (SOSM50), 75% (SOSM75) and 100% (SOSM100) inclusion levels and a commercial feed (CF) as the second control. Three hundred and sixty (360) fingerlings of *C. gariepinus* (mean weight 2.85 ± 0.01 g) were stocked (20) fish per tank in triplicate groups per treatment and fed 3% body weights twice a day. The experimental diets were administered for 180 days feeding and adjusted every 14 days after every weighing. The water qualities were within the ranges recommended for *C. gariepinus*. The highest benefit cost ratio and net profit (1.65 and 77.01) in fish fed 25% fermented SOSM were significantly different ($p < 0.05$) from fish fed commercial feed, 0% FSOSM, 50%, 75% and 100% respectively. In conclusion, 25% replacement of soybean meal with fermented *S. obtusifolia* meal reduced the price of fish feeds by 43.6%. Therefore, 25% replacement of soybean meal with FSOSM is recommended.

Key words: Economic, fermented *Senna obtusifolia*, *Clarias gariepinus* Fingerlings

Introduction

Profitable fish culture requires unflinching supply of formulated fish feed of low cost using the cheapest sources of proteins. To maintain the profitability of raising *Clarias gariepinus*, cutting production costs is necessary, mainly through feeding, which has been acknowledged generally as the major cost incurred during the production cycle (Eyo, 2003; Jamu and Ayinla, 2003; Akinrotimi *et al.*, 2007). Gabriel *et al.* (2007) reported that feed alone in fish farming accounted for between 60-70% of the running expense involved in the operation of fish farm as an enterprise. Reductions in feeding costs can be obtained by optimizing feeding strategies, nutrient levels in diets, and by using plant sources as substitutes for fish oil and fish meal (Martinez-Llorens *et al.*, 2009).

Plant feedstuffs, such as leucaena leaf meal, cranberry bean, and soybean (Amisah *et al.*, 2009; Aremu *et al.*, 2010) have received most attention in recent years in African catfish feeds, however, due to amino acid imbalances, presence of anti-nutritional compounds and low palatability, a high level of replacement of fish meal with plant feedstuffs is generally not well accepted (Belgin *et al.*, 2009).

Soybean meal, being the most nutritive, has been used as the major protein source in many fish diets as partial or total replacement of dietary fish meal. Soybean meal has been used in the diets of Tilapia and catfish species (Soltan *et al.*, 2001; Fagbenro and Davies, 2002; Eyo, 2003; Abdelhamid *et al.*, 2006; Magdy, 2006). Similarly, it has been used in formulating both livestock and fish feeds as well as human food and various industrial uses in Nigeria. These competitions and needs for soybean have soared its demand and cost. Consequently, the search for a novel high quality, cheap and readily available source of plant protein to replace soybean is now a major concern of livestock and fish nutritionists (Adeniji, *et al.*, 2005; Obun and Ogunwale, 2006).

Senna obtusifolia also known as Tafasa in Hausa is an annual plant considered a serious weed in many places and a competitive shrub that grows vigorously across the tropics (Ingweye *et al.*, 2010). The plant grows to a height of about 1.5-2.5m tall and 1m wide. The pod is 10-15cm long, 3-5mm wide, slender and sickle shaped. The plant prefers well drained fertile soil. Treatment of ulcers, ring worm and other parasitic diseases by the dried leaves of *S. obtusifolia* in Northern parts of Nigeria have been reported (Dharmendra, *et al.*, 2010). The proximate composition of the seeds shows a high dry matter (95.50%), crude protein (29.54%) and crude fibre (10.18%), while the leaves contain dry matter (92.40%), crude protein (27.4%) and crude fibre (16.8%), ether extract (3.8%) and nitrogen free extract (36.8%) and high concentrations of anti-nutrients which can be detoxified through processing (Ingweye *et al.*, 2010; Ayssiwede, *et al.*, 2011). Already, domestication of *S. obtusifolia* gave a promising seed yield of 1ton/ha (Pasternak *et al.*, 2007; Paster *et al.*, 2007), unlike soybean, its use for human consumption, animal feed formulation or as protein source in fish feed have not been fully exploited. However, reports show that 25% inclusion of fermented *S. obtusifolia* seed meal in the diets of *C. gariepinus* enhanced growth of the fish without affecting the fish negatively (Onimisi *et al.*, 2017). Thus, formulation of low-cost feeds using cheap and readily available sources of protein is essential to increase fish production. The aim of this study is to evaluate the economic viability of replacing soybean meal with fermented *S. obtusifolia* seed meal in the diets of *C. gariepinus*.

MATERIALS AND METHODS

Collection and Processing of *Senna obtusifolia* Seeds

The seeds of *Senna obtusifolia* were handpicked in Shika Zaria, Kaduna State. The seeds were soaked in water in a 1:6 (seeds: water) i.e. 1kg/6lit ratio for 12h, drained soaked seeds were allowed to ferment naturally for four days (4 days) (Udensi *et al.*, 2006). The fermented seeds were air dried for two days, and were ground into fine powder, and analyzed for proximate composition, amino acids, mineral elements and anti-nutritional compounds.

Experimental Fish

Three hundred and sixty (360) fingerlings of *Clarias gariepinus* with mean initial weight (2.85 ± 0.01 g) were stocked at twenty (20) fish per tank in three replicates per treatment after acclimatization.

Feed Formulation and Pellet Preparation.

The experimental diets contained fish meal (FM), soybean meal (SBM), yellow maize meal (YMM), groundnut cake meal (GNCM) and fermented *Senna obtusifolia* seed meal (FSOSM). All ingredients were ground into a fine powder using a hammer mill and sieved to pass through a 0.25-mm sieve. Prior to feed formulation, proximate compositions of these ingredients were determined (Table 1). Five isonitrogenous diets (42%CP) and Isocaloric (gross energy 2777 kcal kg⁻¹) was prepared where the FSOSM replaced SBM at 0%, 25%, 50%, 75%, and 100%. While 0% (SBM0) and commercial pelleted feed served as the control diets (Table 2).

Table:1 Gross Composition of the Experimental diets

Ingredients	0%	25%	50%	75%	100%
Maize	23	21.0	19.	16	13
Fermented <i>Senna obtusifolia</i>	-	8.75	17.5	26.25	35
GNC	15	17.5	20.5	23	27

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SBM	35	26.25	17.5	8.75	-
Fish Meal	24	24	24	24	24
Palm oil	2	2	1.5	1.5	2
Vitamins	0.25	0.25	0.25	0.25	0.25
Salt	0.2	0.2	0.2	0.2	0.2
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100

Table: 2 proximate compositions of experimental diets

Composition	CF	0%	25%	50%	75%	100%
Crude protein	42.34	42.35	42.28	42.23	42.22	42.24
Moisture	7.86	7.38	7.49	7.90	7.38	7.48
Crude lipid	14.69	11.47	11.46	11.69	11.84	11.79
Crude fibre	2.8	4.91	4.62	4.59	5.32	5.33
Ash	6.7	8.21	8.30	8.46	8.14	8.18
NFE	25.7	25.68	25.85	25.03	25.10	24.98
Dry matter	92.23	92.62	92.51	92.00	91.62	92.12

Experimental procedures

The experimental system consisted of 18 units cylindrical black plastic tanks of 380-L capacity, 50-cm diameter and 50-cm depth each in a complete randomized design. Water was supplied to each tank at a rate of 1-L min⁻¹ from a 2000-L header GP tank. Fish were fed the experimental diet at 3% body weight twice a day for 180 days. Feeding quantity was adjusted after every weighing fortnightly for growth and survival records (mean body weight, mean standard length and mortality). Water pH and temperature was taken daily (8.00-9.00h) using combined pH and thermometer model pH-009(111), the Dissolved oxygen (DO) was determined using the DO meter model DO-510.

Determination of Economic Viability of the Feeds

The economic evaluations of substituting soybean meal with fermented *Senna obtusifolia* seed meal in the culture of the catfish *Clarias gariepinus* were evaluated. The economic benefit of the various diets was determined using the following indices:

- i. Incidence cost (IC) = Cost of feed/weight of fish produced
- ii. Profit index (PI) = weight of fish produced/cost of feed
- iii. Net profit (NP) = sales – expenditure
- iv. Benefit cost ratio (BCR) = total sales/total expenditure (Mazid *et al.*, 1997)
- v. Total cost (TC) = fixed cost (FC) + total variable cost (TVC)
Where FC= cost of fingerlings
TVC = Cost of producing Different diets (Sogbesan and Ugwumba, 2006)

Gross margin analysis and profitability ratio was used to examine the cost and returns of fish production in substituting soybean meal with fermented *Senna obtusifolia* seed meal. Gross margin analysis is given by Eq. vi: $GM = TR - TVC$

Where GM = gross margin

TR = Total revenue TVC = Total Variable Cost

The performance and economic worth of various diets was determined by the use of the following (Abu *et al.*, 2010) vii. $NR = TR - TC$

Where NR = net revenue TR = Total revenue TC = Total cost

Statistical Analysis

All data collected were subjected to Analysis of Variance (ANOVA) using General Linear Model (GLM) procedure of SAS (SAS,2004) DMRT was used to separate means. Economic evaluation indices as described by New (1989), Morraise *et al.* (2001) and Abu *et al.* (2010) were also determined.

RESULTS AND DISCUSSION

Economic Viability of Using Fermented *Senna obtusifolia* Seed Meal

Table 2 presents the economic viability of using fermented *Senna obtusifolia* seed meal. Amongst the experimental feeds the commercial diet was the most expensive (₦360/kg), while the diet containing 100% FSOSM was the cheapest. The cost of feeding reduced progressively as the inclusion of FSOSM increased. The mean cost of fingerling and feeding for the 24 weeks was ₦195.4 in control diet, ₦121.79 in diets containing in 0% FSOSM, ₦118.49 in 25% FSOSM, ₦107.19 in 50% FSOSM, ₦87.36 in 75% FSOSM and ₦70.26 in 100% FSOSM. The benefit cost analysis indicated that the cost of production of the control commercial diet (₦360) and diet containing 0% FSOSM (₦210.65) had the highest cost throughout the experimental period, while the diet containing 100% FSOSM had the least. The mean sales value (₦196.23) was highest in commercial feed and lowest (₦94) in diets 100% FSOSM. The benefit cost ratio (1.65:1) was highest in diets containing 25% FSOSM and lowest (1:1) in commercial diets.

Gross Margin and Net Return Analysis of *Clarias gariepinus* Production

Table 3 presents the gross margin and net return analysis of *Clarias gariepinus* production fed the experimental diets. The mean variable total cost (TVC) of the commercial feed was the highest at ₦175.40, while the least was at the fish fed 100% inclusion of FSOSM. The total cost of production ₦195.40 was also highest in the fish fed the commercial feed and the least was at the fish fed 100% inclusion of FSOSM. However, the net return on investment was highest at the fish fed the 25% inclusion while the least was at the fish fed the commercial diets.

The average total cost per kg of fish produced was ₦116.75, while the average total revenue per kilogram of fish raised was ₦159.42. The average value of gross margin was ₦62.67 while the net revenue was ₦42.67.

Table 2: Economic Viability of Fermented SOSM in the diets of *Clarias gariepinus*

Parameters	CF	0%	25%	50%	75%	100%
Cost of feed(₦)/Kg	360	210.65	203.36	195.30	181.46	180
Mean feed intake(g)	487.23 ^a	483.20 ^b	484.31 ^b	446.46 ^c	371.19 ^d	279.23 ^e
Mean feeding cost(₦)	175.40 ^a	101.79 ^b	98.49 ^c	87.19 ^d	67.36 ^e	50.26 ^f
Cost of fingerling(₦)	20	20	20	20	20	20
Total expenses(₦)	195.40	121.79 ^b	118.49 ^c	107.19 ^d	87.36 ^e	70.26 ^f
Mean final weight(g)	280.33 ^a	279.68 ^a	279.29 ^a	218.54 ^b	173 ^c	135.6 ^d
Cost of fish (₦)/Kg	700	700	700	700	700	700
Mean yield cost(₦)	196.23 ^a	195.78 ^a	195.50 ^a	152.98 ^b	121.1 ^c	94.92 ^d
Net profit	0.83 ^f	73.99 ^b	77.01 ^a	45.79 ^c	33.74 ^d	24.66 ^e
Benefit cost ratio	1.00 ^e	1.61 ^b	1.65 ^a	1.43 ^c	1.43 ^c	1.34 ^d
Incident cost	0.63 ^a	0.37 ^d	0.36 ^d	0.40 ^b	0.38 ^c	0.38 ^c

CF: Commercial Feeds

Table 3: Gross Margin and Net Return Analysis of *Clarias gariepinus* production.

Parameters	Cf	0%	25%	50%	75%	100%	Total
Mean TVC (₦/kg)	175.4	101.79	98.3	87.19	67.36	50.26	96.72
Cost of fingerlings (₦/kg)	20	20	20	20	20	20	20
Total cost(₦/kg)	195.40	121.79	118.49	107.19	87.36	70.26	116.75

Total revenue(₦/kg)	196.23	195.78	195.50	152.98	121.1	94.92	159.42
Gross margin(₦/kg)	20.83	93.99	97.01	65.79	53.74	44.66	62.67
Net return(₦/kg)	0.83	73.99	77.01	45.79	33.74	24.66	42.67

CF: Commercial feeds TVC: Total Variable Cost

The total cost of producing fermented SOSM and purchasing other ingredients progressively reduced from N210.65/kg to N180.00/kg in control to 100% fermented SOSM respectively. This indicates a reduction in the cost of diets of *Clarias gariepinus* fed with alternative plant sources such as *Senna obtusifolia*. For instance, Abu *et al.* (2010) found a reduction in the cost of the diets of *C. gariepinus* when cassava root meal was used to replace maize meal. Similarly, Alegbeleye *et al.* (2011) reported reduction in the cost of feed when *C. gariepinus* was fed fermented pigeon pea meals at various replacement levels of soybean meal. Value of fish (₦/kg) was significantly higher in 25% SOSM compared to other inclusion levels and the control. This observation may be due to the experimental diet which was better utilized at 25% than at other levels, due to the higher values of mean feed intake and mean weight gain. The net returns recorded was highest (₦77.01) at 25% SOSM and least (₦24.66) at 100% SOSM. The possibility of obtaining a significantly higher value of profit index at 25% inclusion level above those of the control and higher inclusion levels clearly indicates that more profit would be generated from fish produced from 25% FSOSM. The best cost benefit and best net profit that was obtained in diet having 25% FSOSM is an indication that the economic viability of feeding *C. gariepinus* with the diet produces better return on investment, this shows that, it is cheaper to feed the fish at 25% replacement of soybean meal with fermented *S. obtusifolia* seed meal (FSOSM) in the diet.

The benefit cost ratio (BCR) value (1.65) shows that catfish production is profitable at 25% inclusion of FSOSM. The value (1.65) simply means that every ₦1.00 invested in the fish production will yield ₦1.62. According to Adegeye and Ditto (1982), this ratio is one of the concepts of discount method of project evaluation. As a rule of thumb, project with benefit ratio greater than one, equal to one, or less than one indicates profit break-even or loss respectively (Olagunju *et al.*, 2007). Since the ratio in the diet is above one, it is therefore considered that replacing soybean meal with fermented SOSM is profitable especially at 25% replacement level. The gross margin was highest at 25% replacement of soybean meal with fermented SOSM. According to Olagunju *et al.* (2007) gross margin is a good measure of profitability; therefore, replacement of soybean meal at 25% is highly profitable

In conclusion, the use of fermented *Senna obtusifolia* meal at 25% replacement in feed formulations to partially replace soybean can bring about a reduction in price of fish feeds by 43.6% thereby enhancing profit margin. It is therefore, recommended that inclusion of FSOSM in the diet of *C. gariepinus* should not exceed 25% level of substitution with soybean.

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EVALUATION OF SOYBEAN MEAL REPLACEMENT WITH SESAME SEED MEAL ON THE WHOLE BODY COMPOSITION AND SELECTED BIOCHEMICAL PARAMETERS OF AFRICAN CATFISH, *CLARIAS GARIEPINUS* JUVENILES.

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ABSTRACT

The study examined the whole body composition and biochemical parameters of *C. gariepinus* fed Sesame seed meal (SSM). One hundred and fifty healthy *C. gariepinus* juveniles of mean weight 34.35 ± 3.05 g were randomly distributed into 15 plastic tanks of 10 fish each and fed twice daily for 56 days. Proximate analyses of the experimental diets and whole body composition of the fish was conducted using the standard method. Selected biochemical parameters of the experimental fish was also analysed using a commercial kit, VetTest Biochemical Analyzer (Idexx Lab., USA). The whole body composition also showed the highest protein level of 18.32% and the least lipid level of 4.05% recorded in fish fed the control diet (0% SSM). The levels of protein and lipid in both the experimental diets and whole body composition of *C. gariepinus* were not significant ($p > 0.05$). Elevated levels of aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP), 53.49 – 59.29U/L, 65.38 – 73.26U/L and 73.67 – 77.75U/L respectively were recorded although not statistically significant ($p > 0.05$). Slight increase in glucose, urea, calcium and phosphorus was also observed. The present study revealed that SSM can be used to replace SBM up to 60% without any adverse effects on the body composition, cellular alterations and physiological disruption. Hence

suggest it could be nutritionally and economically viable means of developing a cost –effective feed to maximize fish growth.

KEYWORDS: Sesame seeds, proximate composition, serum biochemistry, *Clarias gariepinus*,

Introduction

Feed formulation is becoming increasingly expensive and difficult to obtain in many countries practicing aquaculture due to a high price and a drop in fishmeal production making the industry economically unviable (Acar and Turker 2018). Researchers have reported that plant- based protein foodstuffs can be used to replace fishmeal in the diets with a view of reducing the cost of fish feeds. Fagbenro *et al* (2003) reported that seeds from leguminous plants could serve as a good replacer of ever expensive and scare fishmeal. Soybean products have been used to replace a significant portion of fishmeal in fish feed with nutritional, environmental and economic benefits. According to Storebakken *et al.*, (2000) soybean meal (SBM) have been reported to have the capacity to replace fishmeal component without any detrimental effects on the fish due to its high nutrient content. This has resulted to the need to find alternative to soybean meal in the fish feed industries capable of comparing favourably with nutritional qualities of soybean meal, cheap, readily available, ecofriendly and economically sustainable. Studies have shown that plant protein sources have high potentials for supplying fish with required protein needed for their maximum productivity (Ozovehe and Nzeh, 2013). The search for alternatives to soybean is important for the sustenance of aquaculture industry and its profitability. Sesame seed contain 41 – 58% oil, 18 – 25% protein, 13 – 17% carbohydrate, essential fatty acids (Linoleic and Linolenic), amino acids (methionine and lysine), sulphur and calcium (Lee *et al.*, 2003). The replacement of soybean meal with sesame seed up to 16% in the diet of Nile tilapia, *Oreochromis niloticus* is reported to have no negative effects on the growth performance of the fish. Ochang *et al.* (2014) recommended 25% inclusion in *Clarias gariepinus* juveniles without any negative effects on growth and haematology. However 75 – 100% replacement with sesame seed meal (SSM) have been reported to have negative effects on the weight gain of Nile tilapia. Therefore this study aimed to evaluates the replacement of highly competitive and costly soybean with cheap and less competitive defatted sesame seed meal using whole body composition and some biochemical parameters as indices for assessment.

Materials and Methods

Experimental Fish

Three hundred and fifty apparently healthy juveniles of *C. gariepinus* were procured from Famosas family farm in Calabar, Cross River State, Nigeria. They were put in 20 litres jerry cans and transported by Car to the wet laboratory, Department of Fisheries and Aquatic Science, Cross River University of Technology. They were batch weighed and put in aquaria, acclimated for two weeks before the commencement of the research. During the period of acclimation the fish were fed at 5% body weight with top feed with a crude protein of 40% twice daily and discontinuous 24 hours prior to commencement of the experiment.

Collection and preparation of sesame seed meal (SSM)

The sesame seed was purchased from Adun market, Ofodua, Obubra Local Government Area of Cross River State. The sesame seed was sieved to remove dirt and sand, washed and sun dried for 3 days. The seed was ground with a hammer mill and the oil removed using a catalyst n- hexane as recommended by Enujiugha and Akanbi (2005).

Preparation of experimental diets

The isonitrogenous diets of 51.88% crude protein were formulated using the Pearson's square method. The sesame seed meal was included to replace varying quantities of soybean in the diets Table 1. The feed ingredients were ground separately to fine powder using the hammer mill. Each ingredient was weighed into a bowl and all were mixed properly. Boiled water was then added to the mixture and stirred to obtain a consistent dough which was passed through a pelleting machine to produce a 0.5 mm pellets. Thereafter, the feed was sundried for 4 days, then stored in an airtight plastic container and kept until the time for use.

Table 1: Ingredients composition of formulated diets (% Dry weight) and proximate of experimental diets.

Ingredient (g/100g)	D1 (0%)	D2 (15%)	D3 (30%)	D4 (45%)	D5 (60%)
Blood meal (80% CP)	10	10	10	10	10
Fishmeal (64%CP)	25	25	25	25	25
Soybean meal (42%CP)	30	25.5	21	16.5	12
Sesame seed meal (28%CP)	0	4.5	9	13.5	18
Maize (11%CP)	27	27	27	27	27
Soybean oil	3	3	3	3	3
Vit/min premix	2.5	2.5	2.5	2.5	2.5
Lysine	0.3	0.3	0.3	0.3	0.3
Methionine	0.2	0.2	0.2	0.2	0.2
Binder	2	2	2	2	2
Total (%)	100	100	100	100	100

Experimental design and procedure

A completely randomized design (CRD) with five treatments in three replicates (5 x 3) was used. The 15 labelled aquaria were randomly allocated with 20 fish each on the five treatment diets (D1, D2, D3, D4 and D5) in triplicate. Feeding was carried out twice daily, 8:00 – 8:30am, and 5:00 – 5:30pm for 56 days.

Proximate analysis

Samples of the experimental diets and the whole fish (before and after the experiment) in all the treatments were analyzed for proximate composition. Moisture content was determined by oven-drying to a constant weight, crude fat and protein were determined using soxhlet extraction and micro – Kjeldahl method, respectively. Total ash and crude fiber were analyzed using muffle furnace combustion and trichloroacetic acid method, respectively. The carbohydrate was determined by $100 - (\% \text{ moisture} + \% \text{ ash} + \% \text{ fat} + \% \text{ protein} + \% \text{ fiber})$ according to Henken *et al.* (1986) and Effiong *et al.* (2019). The nitrogen free extract (NFE %) was determined by $\% \text{ DM} (100) - (\% \text{ moisture} + \% \text{ CL} + \% \text{ CP} + \% \text{ ash} + \% \text{ CF})$ Where: DM = dry matter, CL = lipid, CP = crude protein CF = crude fibre according to Effiong *et al.* (2019).

Biochemical Parameter.

The clotted blood was centrifuged for 15 minutes at 3500 revolutions per minute (rpm). A clear fluid which is the serum was pipetted out into clean sterilize bottle for further analysis. The stored serum was used for the analysis of some enzymes, metabolites and electrolytes using a commercial kit, VetTest Biochemical Analyzer (Idexx Lab., USA). The enzymes were alanine aminotransferase (ALT), aspartate aminotransferase (AST) and alkaline phosphatase (ALP) while metabolites determined were glucose (Gluc), protein (Prt), cholesterol (Chol), urea (Urea) and triacylglycerols (Trgly). Serum electrolytes determined were Calcium (Ca) and Phosphorus (P).

Data Analysis

The data obtained from the experiment were subjected to multivariate analysis using a statistical software SPSS version 25 to compute for the mean value of the variables proximate and biochemical parameters. The differences among the means were compared using Turkey's multiple comparison test at 5% significance level.

Results

Whole body composition of *C. gariepinus* juveniles

The result of the initial and final mean values of whole body composition (%) of moisture, protein, lipid, ash and nitrogen free extract (NFE) contents is presented in Table 2. The initial values of protein and lipid were lower while those of total ash and NFE were higher than those of the experimental diets. The highest level of crude protein (18.55%) was recorded in fish fed the control SSM diets and was not significant ($p > 0.05$) from the least value of 17.05% obtained from fish 60% SSM diets.

Table 2: Whole body composition (%) of *C. gariepinus* before and after treatment

Parameter (%)	Diets					
	Initial	D1	D2	D3	D4	D5
Moisture	71.65±0.54 ^{ab}	71.63±0.26 ^{ab}	71.67±0.37 ^{ab}	71.82±0.05 ^{ab}	72.10 ±0.16 ^a	72.59 ±0.58 ^a
Protein	16.50±1.08 ^{ab}	18.55 ±1.58 ^a	18.32 ±1.15 ^a	18.06 ±1.22 ^a	17.55±1.45 ^{ab}	17.05 ±1.25 ^{ab}
Lipid	3.38 ±0.42 ^b	4.05 ±0.15 ^{ab}	4.62 ±0.28 ^{ab}	5.04 ±0.21 ^{ab}	6.15 ±0.35 ^a	6.80 ±0.05 ^a
Ash	4.84 ±0.16 ^a	3.76 ±0.22 ^{ab}	3.53 ±0.30 ^{ab}	3.28 ±0.38 ^{ab}	2.85 ±0.25 ^b	2.50 ±0.50 ^b
Nitrogen Free extract	3.63 ±0.85 ^a	2.06 ±0.80 ^{ab}	1.86 ±0.90 ^b	1.80 ±0.55 ^b	1.35 ±0.60 ^b	1.06 ±0.45 ^b

Means with the same superscript are not significant at $p > 0.05$

Biochemical parameters

Result of selected enzymes, (AST, ALT and ALP) metabolites (TP, Glu, Cho, Trgly and Ure) and electrolytes (Ca and P) of *C. gariepinus* fed SSM diets is presented in Table 2. The result showed an increase in plasma enzymes as the level of SSM in the diets increased. Alanine aminotransferase (ALT) showed that fish fed 60% had the highest value of 73.26U/L while the control diet (0%) had the lowest (65.38U/L). Total protein (TP) and Cho decrease from 45.19 – 42.99 and 59.63 – 57.54 while Trgly, Glu and Ure increase from 64.43 – 67.02, 25.94 – 28.31 and 26.48 – 27.90 respectively as the level of SSM in the diets increases. The mean values of Ca in fish fed the various diets were not significant from that of the control diet while the value of P of fish fed 15 and 30% SSM diets were not significantly different ($p < 0.05$) from the control.

Table 3: Selected biochemical parameters of *C. gariepinus* fed SSM diets

Parameter	Diets				
	D1	D2	D3	D4	D5
ALT (U/L)	65.38± 0.45 ^{ab}	65.78 ±0.15 ^{ab}	67.38 ±0.16 ^{ab}	70.69 ± 0.69 ^a	73.26± 0.66 ^a
AST (U/L)	53.49 ± 0.50 ^{ab}	54.62 ±0.37 ^{ab}	55.3 ±1 0.33 ^{ab}	56.53 ± 0.25 ^{ab}	59.29 ± 0.29 ^a
ALP (U/L)	73.67 ±0.31 ^{ab}	74.82 ±0.12 ^{ab}	75.08 ±0.20 ^{ab}	76.73 ±0.46 ^a	77.95 ±0.15 ^a
TP (mg/dL)	45.19 ±0.20 ^a	44.40 ±0.20 ^a	43.77 ± 0.10 ^{ab}	43.30 ±0.54 ^{ab}	42.99 ±0.63 ^{ab}
CHO (mg/dL)	59.63 ± 0.39 ^a	59.63 ± 0.39 ^a	58.55 ±0.13 ^a	57.73 ± 0.08 ^{ab}	57.54 ±0.26 ^{ab}
TRIG (mg/dL)	64.43 ±0.21 ^{ab}	64.76 ±0.40 ^{ab}	65.52 ± 0.84 ^{ab}	67.02 ±0.48 ^a	67.02 ±0.48 ^a
GLU (mg/dl)	25.94 ±0.11 ^{ab}	26.14 ±0.24 ^{ab}	26.33 ±0.3 ^{ab}	26.76 ±0.35 ^{ab}	28.31 ±0.30 ^a
URE (mg/dL)	26.48± 0.18 ^{ab}	26.76 ± 0.19 ^a	27.02 ±0.07 ^a	27.61 ±0.16 ^a	27.90 ±0.18 ^a
Ca (mmol/dL)	16.45 ±0.42 ^{ab}	16.91 ±0.24 ^{ab}	17.07 ±0.04 ^a	18.55 ±0.64 ^a	19.04 ±0.07 ^a
P (mmol/dL)	6.81 ±0.05 ^{ab}	7.14 ±0.16 ^{ab}	7.47 ±0.37 ^{ab}	9.00 ±0.13 ^a	10.17 ±0.18 ^a

Means with the same superscript are not significant at $p > 0.05$

Discussion

Knowledge of proximate analysis of diet helps in the development of cost – effective feed that provides balanced diet to maximize fish growth rate (NRC, 2011). Carcass composition measures the growth and quality of protein, lipid, ash and its utilization in fishes (Ahmed and Maqbool, 2017). According to Degani et al. (1989) the optimum protein requirement for African catfish, *C. gariepinus* ranged between 40 – 45%. In this study the ranged of 50.06 – 53.52% protein was higher the optimum requirement and the 41.09 –

41.54 in Sesame seed meal by Ochang *et al.* (2014) but lower than the 60 – 62% reported for *Moringa oleifera* leaf meal by Ozovehe and Nzeh (2013) and Agwu *et al.* (2017). The variations could be attributed to the different protein levels in the ingredients use for the experimental diets. The protein and lipid requirement for *C. gariepinus* was met by the quantity provided in the diets making it sustainable feedstuff required for growth of the fish.

The decrease in crude protein with an increase in lipid content of whole body composition of *C. gariepinus* fed varying percentage of SSM diets corroborates the findings of Jimoh and Aroyehum (2011) and Yakubu *et al.* (2020). The highest level of crude protein obtained in the carcass of fish fed the control diets may correspond to its highest level in the soybean than sesame seed. The elevated body lipid in African catfish fed Sesame seed and Bambara seed meals was as a result of higher fat content in SSM (Enyidi *et al.* 2014). Similar observation was reported in *C. gariepinus* using sunflower and sesame seed diets (Fagbenro *et al.*, 2010), *C. gariepinus* on *Chrysophyllum albidum* diets (Jimoh *et al.*, 2014) and *Cyprinus carpio* fed various dietary protein level (Ahmed and Maqbool 2017). The non – significant changes in the whole body protein and fat suggest that replacement of SBM with 60%SSM in the diet of *C. gariepinus* could be nutritionally and economically viable means of developing a cost –effective feed to maximize fish growth.

Biochemical parameters

Elevated levels of ALT, AST and ALP was recorded as the levels of SSM increased in the diets although not significant ($p > 0.05$) in this study. This contradicts the findings of Dienne and Olumuji (2014) who reported a significant elevation in AST, ALT and ALP in *C. gariepinus* fingerlings fed varying levels of *Moringa oleifera* leaves diets. According to Mousa *et al.* (2008) significantly higher levels of ALT, AST and ALP enzymes in the serum are suggestive of liver and tissue damage leading to the leakage into the circulatory system. The non – significant changes in this study is an indication that there was no adverse effects on the liver and other tissues. Serum protein, cholesterol and triglyceride are among the main energy sources and play essential role in maintaining the blood glucose level (Shwetha *et al.* 2012). In this study the observed decrease in serum protein and cholesterol was in agreement with the finding of Kurmar *et al.* (2011) who reported a decrease in total protein and cholesterol in Rainbow trout fed diet replacing fishmeal with *Jathropa curcas* kernel. Significant decrease in serum total protein and cholesterol have been recorded in *C. gariepinus* fed dried *Moringa oleifera* leaves (Bamidele *et al.*, 2015) and *Luffa cylindrical* seed meal (Jimoh *et al.*, 2020). Significant decrease in serum protein reported in fish may be attributed to the disturbances in protein synthesis within the liver and also a physiological strategy to adapt to alterations in their metabolic systems (Adesina, 2017). According to Kurmar *et al.* (2011) the cholesterol lowering effects of plant protein sources is because they inhibit the absorption of cholesterol from the intestine by increasing the excretion of bile salt from the body. The serum triglycerides, GLU, URE, Ca and P all increased with the replacement of SSM in the diet although not significant ($p > 0.05$). Increase in the mean values of triglyceride in this study compliments the increase in crude lipid in the diets and whole body composition. Previous studies have reported increase in triglyceride, glucose and urea on Tilapia (Akinleye, 2012), Rainbow trout (Kurmar *et al.*, 2011), *C. gariepinus* (Jimoh *et al.*, 2020). Jahanbakshi *et al.* (2013) reported significant increase in glucose in sturgeon fish, *Huso huso* fed diets of fishmeal substituted with sesame oil cake and corn meal. The non –significant changes in glucose recorded in this study shows that the fish were not stress and L – amino acid was not mobilized since the fish was not in any adverse condition.

CONCLUSION

The proximate composition of the diets and fish did not show any significant changes ($p > 0.05$) from the control. Elevated level of serum AST, ALT and ALP were also not significant from those fed the control diets. Cholesterol level decrease as the SSM % in the diet increased. The non – significant changes in the whole body protein, fat and biochemical parameters investigated in this study suggest that replacement of SBM with 60%SSM in the diet of *C. gariepinus* could be nutritionally and economically viable means of developing a cost –effective feed to maximize fish growth.

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A REVIEW ON FISH CAGE CULTURE AND RISK MANAGEMENT IN NIGERIA

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ABSTRACT

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. As more awareness is emerging on fish cage culture and people have started delving into this venture, there is the need for awareness of risk management for a better success. Fish cage culture, like other business endeavors, is entered into for financial gain; therefore, managing risks is critical for success.

Keywords: Fish cage culture, Risks, Management, Nigeria.

INTRODUCTION

Today cage culture is receiving more attention by both commercial producers and researchers. Factors such as increasing consumption of fish, declining stocks of wild fishes and poor farm economy has increased interest in fish production in cages. According to Otubusin (2001) and Harrell, (2004) the opportunities and versatility of fish cage farming include opportunity to practice in existing water bodies: marine, brackish or freshwater, higher stocking density of fish compared to pond culture system, higher productivity than in the pond culture system considering the input and surface area involved. Fish can be cultured in one of four culture systems—ponds, raceways, re-circulating systems or cages. A cage or net pen is a system that confines the fish or shellfish in a mesh enclosure.

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 large number of fishes and can be installed in reservoir, river, lake or sea.

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 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 way to utilize natural currents, which provide the fish with oxygen and other appropriate natural conditions.

In view of the high production attainable in cage culture system, it can play a significant role in increasing the overall fish production (Das et al 2009). 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 fisherfolks as an alternative income source. This can be taken up as an household / women activity since labour involved is minimal and can be managed by a small family. The design of the cage and its accessories can be tailor-made in accordance to the individual farmer's requirements. Compared to fish pond culture with its 4 000-year tradition, fish pen/cage culture is of more recent origin. In high intensity aquaculture, fish are held at high densities (200 to 400 fish/m³) in raceways, tanks or cages, and given a high quality feed for rapid growth. All three systems require a species of fish that grows rapidly, accepts artificial feed, tolerates crowding, and has a high market value. Given suitable sites, cage culture can be the most attractive of the three systems. It requires less technology, has low capital costs in small-scale production, and requires virtually no land investment.

According to Mafolabomi et al (2009) the first cages were probably been used by fishermen as temporary holding facilities for fish until enough quantities were caught or gathered for transportation to the market for sale. In some coastal areas like Ilaje Local Government (ILG) Area of Ondo State, local cage facilities have been used as temporary fish containers for several years. This Storage facility avails the farmers the opportunity to take care of unsold fish till the next market day or when demand is made. This method could be exploited to take care of fish for longer period of time. Such that instead of regular fishing in the open waters, fish could be cultured and taken care of near homestead (Mafolabomi et al 2009).

Objectives

The objective of the paper are to raise the 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.

Advantages

Fish cage culture has advantages which include: many types of water resources can be used, including lakes, reservoirs, ponds, strip pits, streams and rivers, lagoons which could otherwise not be harvested.

The fish cage system requires low initial capital than starting a pond culture operation. 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. Observation and sampling of fish is simplified, allows the use of the pond for sport fishing or the culture of other species, less manpower requirement, generation of job opportunities for unemployed youth and women, additional income to fishers during closed seasons. According to Surjya Narayan Datta *et al* (2014), the performance of fish raised in pond with cage were better than those raise without cage.

Growth of carps and *C. punctata* in experimental ponds

Species	Minimum growth		Maximum growth		Average growth	
	Pond with cage	Pond without cage	Pond with cage	Pond without cage	Pond with cage	Pond without cage
<i>C. catla</i>	108.40±0.781	214.63±1.184	651.33±1.527	681.57±1.913	510.57±1.159 ^b	445.15±1.033 ^a
<i>L. rohita</i>	40.16±0.763	56.00±0.90	171.33±1.527	181.73±1.457	90.483±0.401 ^d	94.640±0.555 ^c
<i>C. mrigala</i>	71.260±0.65	83.766±0.59	138.63±3.808	134.03±0.950	110.13±0.808 ^f	105.31±1.370 ^e
<i>C. carpio</i>	221.43±1.69	235.97±1.850	756.77±1.078	478.80±1.081	454.17±1.040 ^h	344.27±1.101 ^g
Average carp growth -	---	-----	275.66±2.31	---	---	239.13
<i>C. punctata</i>	55± 1.23 ^a		92±1.95		83.34±1.02 ^c	

Source (Surjya Narayan Datta et al 2014)

Site Selection

Proper site selection is recognized as the first step guaranteeing the eventual success of any aquaculture project and forms the basis for the design, layout, and management of the project. The right choice of site contributes significantly in the success of cage farm. Site selection is vitally important since it can greatly influence economic viability by determining capital outlay, by affecting running costs, rate of production and mortality factors.

Different criteria must be addressed before site selection for cage culture.

The physico-chemical parameters like temperature, salinity, oxygen, wave action, pollution, algal blooms, water exchange, etc. that determine whether a species can thrive in an environment.

Other criteria which must be considered for site selection are: weather conditions, shelter, depth, substrate, etc.

- Finally legal aspects, access, proximity to hatcheries or fishing harbor, security, economic, social and market considerations etc. are to be taken care of.

Criteria for selection of species for cage culture

The choice of species for stocking and rearing in pens and cages is governed by much the same criteria as in species selection for pond culture, including: (i) fast growth in confinement; (ii) good consumer acceptance; (iii) high tolerance to a wide range of environmental conditions; (iv) resistance to disease; (v) ready supply of fish seed for stocking; and (vi) ease of culture and management (vii) hardiness, (viii) efficient food conversion ability, (ix) availability of quality seeds, (x) market demand (xii) omnivore or carnivore; (xii) Acceptance of supplementary feed; (xiii) Ability to make use of available natural fish food in the water body. Tarpon *Megalops atlanticus* could be a good candidate for cage culture (Balogun et al. 2008). Catfish and different species of Tilapia are also been cultured in the cage.

The risk analysis process

Risk analysis is used to determine the likelihood that an undesired event will occur and the consequences of such an event. This is generally developed in a repeatable and iterative process where we seek answers to the following questions: What can occur? (Hazard identification), How likely is it to occur? (Risk assessment: likelihood assessment through release assessment and exposure assessment). What would be the consequences of it occurring? (Risk assessment: consequence assessment and risk estimation; risk management: risk evaluation). What can be done to reduce either the likelihood or the consequences of it occurring? (Risk management: option evaluation, Implementation, Monitoring and review).

Categories for identification of risks

Cage culture like other aquaculture is a high risk business, not because it is based on biological processes or survival of large numbers of living organisms in captivity but because of its dependence on human skills, efficiency of machines and clemency of the physical forces of nature (Agbebi and Fagbenro 2006).

Climatic change, metrological condition, drought, deposition of silts, poaching, random malicious damage, chemicals, frauds etc

Feed must be nutritionally complete and kept fresh, Low Dissolved Oxygen Syndrome (LODOS) is an ever present problem and may require mechanical aeration, fouling of net cage, the incidence of disease can be high and diseases may spread rapidly, vandalism or poaching is a potential problem, navigation issues, accumulation of unused feed and excreta will lead to water pollution as well as eutrophication, change in water quality parameters, conflicts within the local community, predation by aquatic mammals and birds, escapement and overcrowding of aquatic organisms in cages.

Management of risks

Category A

Pathogen Risks include: The incidence of disease can be high and diseases may spread rapidly. Monitoring of fish stock health is essential and early indications can often be observed from changes in behavior, especially during feeding. Although stocking densities should be determined by species requirements and operational considerations, the influence of stocking densities on growth and production has been determined empirically. The stocking density depends also on the carrying capacity of the cages and the feeding habits of the cultured species. Optimal stocking density varies with species and size of fish. Disease resistant fish species should be cultured in the cage. Overstocking should also be avoided. Unwanted species should be prevented from infiltrating into the cages.

-Food safety and Public Health: The water the cages are being lunched should be such that runoff from industries and every other waste are highly monitored. It is important that farmers must ensure high quality products to avoid the risk of losing their current and potential customers. Their products must leave the farms in perfect condition for post-harvest handling (slaughtering, processing, packaging and transportation) in perfect condition.

Category B

-Financial (Operational costs and Credits): As cheap as it may appear to construct when compared to other culture methods, individual farmer may still find it difficult to fund one. Cage culture farmers can organize themselves into cooperative associations in order to enhance financial capacity and easy acquisition or access to the key and natural resources of water. The cages can also be insured, this is a satisfactory and reliable means of sharing risks with others or managing risks. The merit of the scheme is that, it boosts the confidence of lending institutions to make loans available to farmers where need be

-Social: Good relationship with the community will enhance a wider security overview of the facility and reduces the possibility of poaching, envious and unprovoked attacks on the cages.

Category C

-Ecological - including: moving water weeds, fouling of cage nets and other structures has been observed at many instances of cage farming. Nets get covered with biofoulers. Fouling by molluscs, especially edible oyster and sand barnacles have to be checked before its growth advancement. Regular washing of the net should be done to wash away faeces, uneaten food and to a certain extent reduce the impact of fouling, this will enhance a good water exchange in net. Low Dissolved Oxygen Syndrome (LODOS) is an ever present problem and may require mechanical aeration.

Cage: Cage culture management must result in optimizing production at minimum cost. The management should be so efficient that the cultured fish should grow at the expected rate with respect to feeding rate and stocking density, minimize loss due to disease and predators, monitor environmental parameters and maintain efficiency of the technical facilities. Physical maintenance of cage structures is also of vital importance. The net-cages must be routinely inspected. Necessary repairs and adjustments to anchor ropes and net-cages should be carried out without any delay. Monthly exchange of net should also be considered, as this ensures a good water exchange in the net, thereby washing away faeces, uneaten food and to a certain extent reduce the impact of fouling.

A case study of fish cage culture in Badagry area of Lagos state

Ten (10) youths were given 10 cages each of four by four by two meters in a state government empowerment program. Each cage was stocked with 1500 pieces (3-5gm size) of tilapia (*Oreochromis niloticus*). 40 bags of feed/cage, each of 15 kg were supplied, that's average of 0.4kg/fish. They were fed twice per day. A bag of feed cost #8000, at 0.4kg/fish, that translate to #214/fish, 40bags cost #320,000. The culture period was about seven months; no sorting was done throughout the period.

At the end of seven month culture period, several of the fish weighed between 1 and 1.5 kg, they sold at #1200/kg. Even if the total number weigh average of 500g/fish, that will be more than 700kg total/cage. At #1200/kg, a sum of #840,000/cage realized.

RECOMMENDATION

The activities and menace of poachers and saboteurs must be put to check by a regularly monitoring and patrolling farms. Proper understanding of incidence of pollution from other neighbouring industries to reduce the liability exposure of the farm. Government support inform of financial aid will go a long way to support existing cage owners and motivate many would-be to cause expansion of the culture system.

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EFFECTS OF FERTILIZER AND ORGANIC MANURE APPLICATION ON THE CRUDE PROTEIN CONTENT OF SELECTED CULTURED DUCKWEED SPECIES

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ABSTRACT

Fish feeds account for the highest operational costs in aquaculture with protein being the most expensive diet. Reports from different authors confirmed that the dry matter of duckweed contains between 35-45 % crude proteins depending on the culture system and available nutrients. Duckweed protein was found to have high concentration of essential amino acids, lysine and methionine than most of plant protein and closely resembles animal protein in that respect. This study was conducted to determine the effect of inorganic fertilizer and organic manure application on the nutritional quality of two duckweed species; *Lemna minor* and *Wolffia arrhiza* in a cultured environment and evaluated by proximate analysis. Five separate 6m x 9m concrete tanks with depths of 3m was used for the experiment with water level marked at 0.5m and plants were allowed to grow for a period of 30days. Treatments of seed stock with inorganic fertilizer (NPK 15:15:15) was randomly applied to each collected duckweed species in two separate tanks throughout the growing period. Treatments of seed stock with organic fertilizer (Cow dung manure) was randomly applied to each collected duckweed species in two separate tanks throughout the growing period. A Control tank was maintained also with seed stock with no fertilizer or manure application throughout the growing period. Fresh duckweeds were harvested from each experimental tank including the control tank at 10days interval throughout the growing period for analysis. The study shows there are differences in the nutritional composition of the two duckweed species with *lemna minor* having more nutritional quality having 46.0% CP than what was observed in *Wolffia arrhiza* having 40.1 CP. using (NPK 15:15:15) while using cow dung *lemna minor* has more nutritional quality having 41.6% CP than what was observed in *wolffia arrhiza* having 39.5% CP while in the control *lemna minor* more nutritional quality having 26.3% CP than what was observed in *Wolffia arrhiza* having 25.2% CP. Crude protein most especially was higher in the species grown with fertilizer amendments and lower in the species grown without fertilizer application. It can be concluded from the study that the nutritional quality of duckweed is more dependent on the mineral composition of the growth medium rather than the species. It is recommended that fertilizer application may be used for duckweed farming so as to increase its nutritional attribute in order to make it nutritionally rich enough to serve as source of crude protein in fish diets.

KEYWORDS: Duckweed, crude protein, aquaculture, poultry, feed formulation.

INTRODUCTION

There are several plants both terrestrial and aquatic growing and constituting various nuisance as weeds in the environment. Some of this plant have been seen to be practically useful in other regions through the traditional knowledge of a local culture and people. Hence, some of the plants termed weed can actually be useful and become a special crop grown for its various benefits.

Nigerians have been reported to be one of the largest consumers of fish and fish products (Kudi *et al.*, 2008; Federal Department of Fisheries – FDF, 2007) and this has made us one of the largest importers of fish

among developing countries (Tunde *et al.*, 2015) Fish feeds account for the highest operational costs in aquaculture with protein being the most expensive diet (Munguti *et al.*, 2012). Seeking alternative protein source for feeding in poultry and aquaculture has been the focal point of research in Nigeria in recent times and it is important for such supplement to contain optimum protein, required essential amino and fatty acids (Effiong *et al.*, 2009). Duckweed is seen to be a potential candidate to serve as an alternative source of crude protein in poultry and aquaculture diets. They are tiny free-floating vascular plants found throughout the world growing in thick, blanket-like mats on still, nutrient-rich fresh and brackish waters.

Feed costs account for as high as 60 to 70% of the total of poultry chicken production whilst protein accounts for 15% of this cost (Ojewola *et al.*, 2005). The scarcity and high cost of convectional animal protein supplement particularly fishmeal and fish oil has increased. Therefore it is imperative that other protein sources which are cheap and easy to establish be explored to get maximum returns with minimum costs. Duckweed meal has been known for its high nutritive value with as much as 40% and above crude protein depending on the culture system and available nutrients (Leonard, 1995, Ahamad *et al.*, 2003). This present study aims at providing duckweed meal as an alternative source of crude protein for fish feed production to meet the ever increasing demand of crude protein by fish farmers either as single nutritional input or as supplements or feed additives

The specific objective:

To determine the effect of inorganic fertilizer and organic manure application on the nutritional quality of two duckweed species; *Lemna minor* and *Wolffia arrhiza* in a cultured environment evaluated by proximate analysis

MATERIALS AND METHODS

Description of experimental site

The experimental site is Aquatic Vegetation Programme, NIFFR, New-Bussa, Niger State, Nigeria located between LAT 9° 87' - 9° 89' N and LONG 4° 50'- 4° 52' E , 238m A.S.L



Species identification and collection

Duckweed seed stocks was identified and collected from Monai fishing village, New-Bussa, Niger State, Nigeria. The collected samples was transported in oxygen polythene bags and ice-blocks to Aquatic Vegetation Programme, NIFFR, New-Bussa, Niger State, Nigeria which is the experimental site. The collected duckweed seed stocks was cultured in concrete tanks for the experiments.

Monitoring water quality parameters

Certain mean water parameters such as temperature, pH, dissolved oxygen and Total dissolved solid were measured during the experimental period following the standard procedures as described by (APHA, 1988)

Nutrient application to collected duckweed species

Five separate 6m x 9m concrete tanks with depths of 3m was used for the experiment with water level marked at 0.5m and plants were allowed to grow for a period of 30days. Treatments of seed stock with inorganic

fertilizer (NPK 15:15:15) was randomly applied to each collected duckweed species in two separate tanks throughout the growing period. Treatments of seed stock with organic fertilizer (Cow dung manure) was randomly applied to each collected duckweed species in two separate tanks throughout the growing period. A Control tank was maintained also with seed stock with no fertilizer or manure application throughout the growing period. Fresh duckweeds were harvested from each experimental tank including the control tank at 10days interval throughout the growing period for analysis. Excess water was drained out and fresh weight of plant recorded. Dry matter weight was also recorded after sun-drying the harvested plants.

Proximate analysis (crude protein, ether extract, crude fibre and ash)

Yield from all treatments was dried to constant weight. The dried duckweeds was grounded into fine particle and sieved through a mesh size of 2 mm and stored in polyethene bags before being analyzed to estimate its nutritional composition.

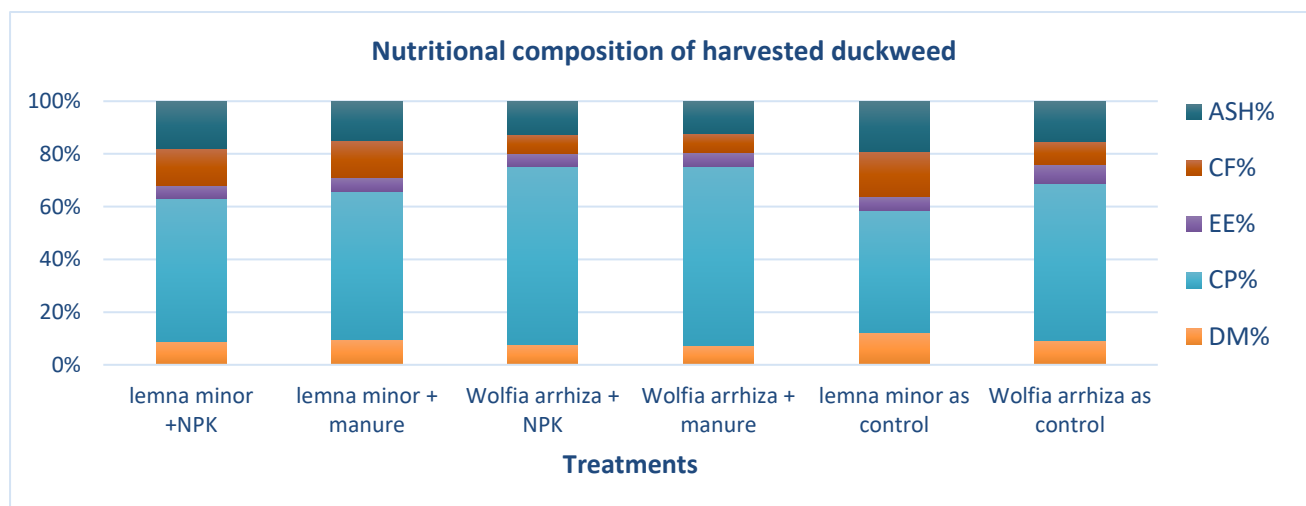
Statistical analysis

The results of the nutritional composition of harvested duckweed species were presented in simple tables. Pearson's product moment correlation coefficient was used to determine the relationship between the treatments and the percentage crude protein content from proximate analysis in both species for all treatments. T-test was used to determine the significant differences on crude protein content between the inorganic fertilizer and organic manure application for both species.

1. RESULTS AND DISCUSSION

Table 1: Mean variation of physiochemical parameter of experimental water in tanks during growth period of 30 days.

PARAMETERS	First 10 days	Second 10 days	Third 10 days
pH	8.1±0.5	8.0±0.3	8.2±0.1
Water Temp (°C)	27.5±2.3	27.0±2.5	27.0±2.3
TDS (mgL ⁻¹)	75.0±0.3	76.0±0.4	77.0±0.2



KEY: DM=Dried matter, CP=Crude protein, EE=Ether extract, CF=Crude fibre

Figure 1: Comparison of nutritional composition of harvested duckweed from various treatments

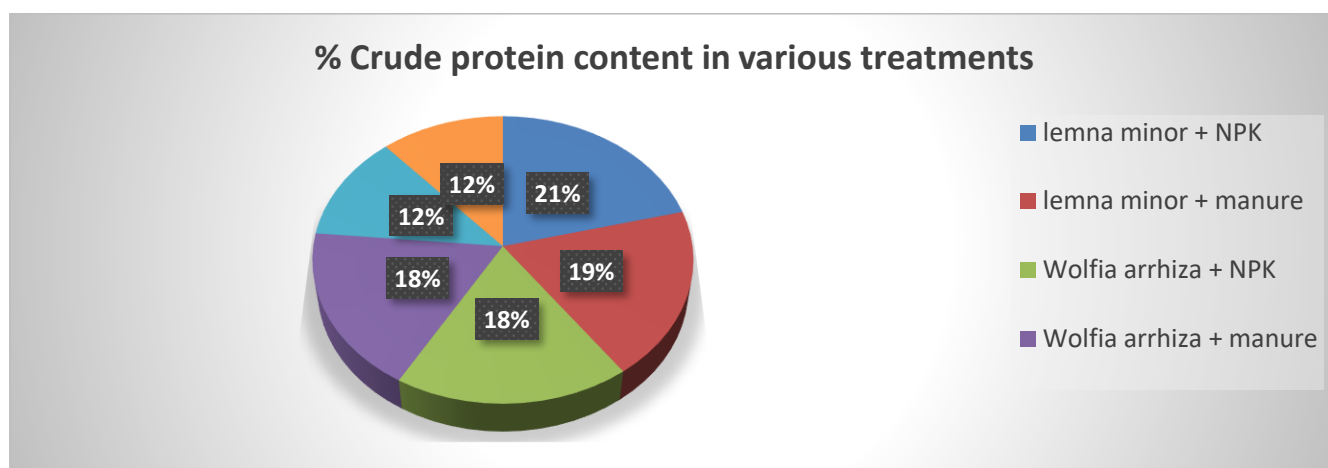


Figure2. Percentage crude protein content in various treatments.

The pH range of 8.00-8.21 was recorded during the experimental period. The water temperature ranged from 25.00-29.50 while the TDS throughout the experimental period was 74.20-77.02 as reported in Table 1. All the physiochemical parameters are in the range required and tolerated for duckweed to grow. The nutritional composition of harvested duckweed from all treatments was evaluated and results are shown on table 2 and figure 2. The highest crude protein content of 46.0% was observed in *lemna minor* with NPK fertilizer treatment followed by *lemna minor* with manure recording crude protein content of 41.6% while the lowest was observed in the control with no fertilizer with 25.2 % crude protein. *Wolffia arrhiza* followed the same trend. The highest crude protein content of 40.1% was observed in *Wolffia arrhiza* with NPK fertilizer treatment followed by *Wolffia arrhiza* with manure recording crude protein content of 39.5% while the lowest was observed in the control with no fertilizer with 25.2 % crude protein. In general *lemna minor* was found to contain more crude protein at all treatments than *Wolffia arrhiza*. The treatments with NPK fertilizer have more crude protein content than those with organic manure. The lowest crude protein content was observed in the control for both plant species. This is in line with the findings of Leonard, 1995 and Ahamad *et al.*, 2003 who reported that duckweed meal has been known for its high nutritive value with as much as 40% and above crude protein depending on the culture system and available nutrients and also Hasan *et al.*, 2009 who reported that the nutritional content of duckweed is probably more dependent on the mineral concentrations of the growth medium rather than on the species or their geographic location. As a result, water low in nutrients generally results in reduced nutritional content in duckweed.

CONCLUSION AND RECOMMENDATION

The study shows there are differences in the nutritional composition of the two duckweed species with *lemna minor* having more nutritional quality than what was observed in *Wolffia arrhiza*. Crude protein most especially was higher in the species grown with fertilizer amendments and lower in the species grown without fertilizer application. It can be concluded from the study that the nutritional quality of duckweed is more dependent on the mineral composition of the growth medium rather than the species.

It is recommended that fertilizer application should be used for duckweed farming so as to increase its nutritional attribute in order to make it nutritionally rich enough to serve as source of crude protein in fish diets.

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STUDIES ON SOME BLOOD PARAMETERS OF THE NILE TILAPIA (*OREOCHROMIS NILOTICUS*) FED WITH ROSELLE (*HIBISCUS SABDARIFFA*) SEED MEAL AT VARIOUS INCLUSION LEVELS

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ABSTRACT

Oreochromis niloticus with an average weight of 0.60g were reared in 15 plastic aquaria of 60cm x 50cm x 30cm dimension with 120l water holding capacity, five treatments with three replications for a period of 28 weeks. Five experimental diets were used to investigate the effects of various inclusion levels (0%, 25%, 50%, 75% and 100%) of *Hibiscus sabdariffa* seed meal on the haematological properties of *O. niloticus*. At the end of the 28 weeks feeding trial, fish from each treatment were randomly selected for blood analysis. The blood of each fish was drowned into ethylenediamine tetra acetic acid (EDTA) bottles by the use of syringe and needle for determination of packed cell volume (PCV) Red Blood Cell (RBC) white Blood Cell (WBC), Haemoglobin (MCH), Mean corpuscular haemoglobin concentration (MCHC), and mean corpuscular volume (MCV). The results obtained showed that the packed cell volume (PCV) of fish fed with 50% inclusion level of *H. sabdariffa* was higher (40.00%) followed by the control 0% inclusion level (38.50%) then 25% (37.50%) 75% (34.00%) and 100% (32.00%). There was significant difference ($P < 0.05$) in all the values for PCV. Other blood parameters followed the same pattern: RBC 4.70 (50%) 4.35 (0%) 4.19 (5%) 3.37 (75%) and 3.10 (100%). The Hb values were given as 7.70, 7.15, 8.20, 7.43 and 7.20 for 0%, 25%, 50%, 75% and 100% respectively. However, the lymphocytes and white blood cell values were lower in 50% level of inclusion (81.00) 83.50 (0%) 84.45 (25%) and 89.70 for 100% levels of inclusion. The findings revealed that it is possible to replace fish meal with processed *Hibiscus sabdariffa* (Roselle) seed meal in the practical diet of *O. niloticus* without having any detrimental effect on the blood parameters of the fish.

KEYWORDS:

INTRODUCTION

Oreochromis niloticus is one of the most important cultured Fish species cultivated all over the world, especially due to its hardiness and rapid growth, with a high-quality meat (Castro, *et. al.* 2011). The tilapias have good resistance against disease, but the intensive culture and rapid growth may influence the immune status and increase the susceptibility to diseases. The blood parameters of fish are important for evaluating the physiological and pathological conditions, as well as determining the effect of diet and other

environmental factors in cultured fish (De-Pedro, *et. al.*, 2005). A part from diet composition and environmental factors, reproductive cycles and variations in fish activity can also affect their blood parameters (Rehulka, 2003).

Several studies have reported changes in blood parameters indices of fish as a result of feed (Gabriel, *et. al.*, 2011; Dieyl and Olumuyi, 2014). Therefore, determining the basic parameters of blood is important in order to monitor the health status of farmed fish. For example, packed cell volume (PCV) is important indicator of anaemia, hypoproteinemia and leukocytosis of fish (Dieyl and Olumuyi, 2014). Bahmari *et. al.* (2001), reported that analyzing the haematological and biochemical indices in the blood of farmed fish is good for identifying the health status of farmed fish as they provide reliable information on metabolic disorders and deficiencies. However, the composition of blood can be charged by dietary treatment, malnutrition and disease condition (Castro, *et. al.* 2011). Ferreira *et. al.* 2007), reported that biochemical parameters provide early warning of potentially harmful changes in stressed organisms. Bello-olusoji, *et. al.* (2006). Further explained that changes in the haematology of fish in response to stressing agents are indicators of stressful stage of fish producing useful information to curb any unfavorable condition that may affect the fish health. Saravanan *et. al* (2011) used haematological, biochemical and enzymological parameters of Indian major carp *Cirrhinus mrigala* to evaluate the toxicity of new leaf extracts.

Hibiscus sabdariffa seed meal as an alternative to conventional fishmeal is tested in this study. The seed is said to have high protein values, many studies have been carried out to assess the nutritional value of Roselle seeds (El-Adawy and Khalil 1994; Abu-Tarboush *et al.*, 1997). Kwari *et al.*, (2011) reported *Hibiscus sabdariffa* seeds had 38.59% Crude Protein, however, in Nigeria larger quantities of the seed of this crop are wasted on farm annually and just enough being collected and stored for planting as border crop. This study evaluated the effect of various inclusion levels of this seed meal (*Hibiscus sabdariffa*) on the blood parameters and organ indices of the Nile Tilapia (*Oreochromis niloticus*) in order to ascertain the impact of this plant on the wellbeing of the fish.

MATERIALS AND METHODS

Study Area.

The Study was conducted at the Aquaculture Unit, Skill Acquisition Centre, National Agricultural Extension and Research Liaison Services, Ahmadu Bello University, Zaria. The area is located within the Northern Guinea Savannah Zone of Nigeria at latitude 11° 09' 06'' N and longitude 7° 38' 55'' E at an altitude of 706m above sea level.

Experimental Fish

Four hundred and fifty (450) fingerlings of *O.niloticus* was purchased from Federal Department of Fisheries (FDF) fish farm, Kaduna, The fish were transported very early in the morning to the experimental site where they were acclimatized for two weeks before the onset of the experiment.

Experimental diets.

Five Iso – nitrogenous diets were compounded using the fermented *Hibiscus sabdariffa* seeds. Each experimental diet contained 35% crude protein level, which was calculated according to Pearson's square method as described by (Bolorunduro, 2002). Fishmeal based diets without the Roselle seed meal was used as the control. The *H. sabdariffa* seed meals was used to replace fish meal at 0, 25, 50, 75 and 100% inclusion level.

Experimental design.

15 plastic aquaria of 60cmx50cmx30cm dimension with 120l water holding capacity was used. Continuous aeration using whirl charging electro-magnetic aerator (Model-ACO 003) was used through air stones (to ensure adequate distribution of oxygen). Ten fingerlings (Initial weight 0.60g) were stocked in each of the five treatments with three replicates. Each experimental diet was fed to a triplet group of fish, making a total of 15 plastic aquaria. The fish were fed at 3% body weight twice in a day: 9:00am and 6:00pm for a period of 28 weeks.

Haematological Examination

One test organism was removed, from each tank for blood analysis. 5-10ml blood per fish was collected from cardiac puncture in juvenile using 2ml disposable heparinized syringe treated with ethylene diamine

tetra acetic acid (EDTA) as anti-coagulant. The blood was stored at -4°C in deep freezer prior to analysis. The blood analysis follows the method described by Hrubec *et. al.*, (2000).

Packed Cell Volume (PCV)

Non-clotted blood was drawn by capillary action into micro haematocrit tubes; one end of the tubes was sealed with synthetic sealant. The sealed tube was centrifuged in a micro haematocrit centrifuge. Centrifugation lasted for 5 minutes at 10500 rpm. The packed cell volume was measured using micro haematocrit reader and expressed as percentage.

Mean Corpuscular Haemoglobin Concentration (MCHC)

This refers to the percentage of haemoglobin in 100ml of red blood cell. This was calculated by dividing the haemoglobin content (in g/100ml) by the PCV/100ml of red blood cell according to the formula:

$$\text{MCHC} = \frac{\text{Hb}}{\text{Hct}} \times 100$$

Mean Corpuscular Volume (MCV)

The value of the mean corpuscular volume was calculated from the haematocrit value (PCV) (%) and the Red Blood Count (RBC) ($10^6/\text{mm}^3$), according to the following formula:

$$\text{MCV} = \frac{\text{Hct}}{\text{RBC}} \times 100$$

Mean Corpuscular Haemoglobin (MCH) Mean corpuscular haemoglobin concentration, expressed the concentration of haemoglobin in unit volume of erythrocyte. It was calculated from the haemoglobin value (Hb) and from the red blood cells according to the following formula: -

$$\text{MCH} = \frac{\text{Hb}}{\text{RBC}} \times 100$$

Red Blood Cell Count (Red Blood Cell (RBC) and White Blood Cell (WBC)

Haemocytometer was used for blood cell counts. The apparatus consists of a counting chamber; a cover slit white and red blood and a plastic mouth piece for drawing the fluid into pipette. The blood diluting fluid was prepared as described by Hrubec *et. al.*, (2000). The blood cells were counted on the counting chamber of haemocytometer with the aid of compound microscope.

RBC = Number of cells counted $\times 3 \times 10 \times 200$ (10^6 mm^3)

WBC = number of cells counted $\times 0.25 \times 10 \times 20 \times 20$ (10^3 mm^3)

Statistical Analysis

Data obtained from the experiment conducted was subjected to one-way Analysis of Variance (ANOVA). Where the ANOVA reveals significant difference Duncan multiple range tests was used to compare differences among individual treatment means.

RESULTS

Table 1 shows the blood parameters of *O. niloticus* fed with different inclusion levels of fermented *H. sabdariffa* seed meals. The packed cell volume (PCV) of tilapia fed 50% inclusion level of *H. sabdariffa* was higher (40.00) followed by 0% inclusion level (38.50), then 25% (37.50) 75% (34.00) and 100% (32.00). There was significant difference in all these values for PCV. Other blood parameters followed the same pattern; RBC (4.70) for 50% (4.35) 25 %, 4.19 (0%) 3.37 (75%) and 3.10 (100%). The Hb. values were given as 7.70, 7.15, 8.20, 7.43, and 7.20 for 0%, 25%, 50%, 75% and 100% respectively.

Table 1: Blood Parameters of *O. niloticus* fed Different Inclusion Levels of Roselle Seed Meals.

Parameters	0%	25%	50%	75%	100%
Red blood cell	4.19 ^c ±0.05	4.35 ^b ±0.05	4.70 ^a ±0.05	3.37 ^d ±0.05	3.10 ^e ±0.05
White blood cell	3.85 ^c ±0.26	3.41 ^d ±0.26	3.12 ^e ±0.26	4.20 ^b ±0.26	4.36 ^a ±0.26
PCV	38.50 ^b ±0.32	37.50 ^c ±0.32	40.00 ^a ±0.32	34.00 ^d ±0.32	32.00 ^e ±0.32

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Hb	7.70 ^b ±0.00	7.15 ^e ±0.00	8.20 ^a ±0.00	7.43 ^c ±0.00	7.20 ^d ±0.00
MCH	280.38 ^a ±0.33	240.30 ^b ±0.33	280.40 ^a ±0.33	230.15 ^c ±0.33	210.35 ^d ±0.33
MCHC	34.00 ^b ±0.14	32.45 ^c ±0.14	34.60 ^a ±0.14	31.42 ^d ±0.14	30.75 ^e ±0.14
MCV	90.10 ^b ±0.00	90.00 ^c ±0.00	90.50 ^a ±0.00	89.90 ^d ±0.00	89.30 ^e ±0.00
Lymphocytes	83.50 ^c ±0.27	84.45 ^b ±0.27	81.00 ^d ±0.27	89.00 ^a ±0.27	89.70 ^a ±0.27

Means on the same row with the same superscripts are not significantly different (p<0.05)

PCV---Packed Cells Volume

Hb---Haemoglobin Concentration.

MCH-Mean Cell Haemoglobin

MCHC Mean Corpuscular Haemoglobin Concentration

MCV-Mean Corpuscular Volume

DISCUSSION

In this experiment to determine the effect of various inclusion levels of *H. sabdariffa* (Roselle) seed meal, the Haemoglobin concentration (Hb.) Packed Cell Volume (PCV) and Red Blood Cells (RBC) were higher at 50% inclusion level, the values decreased significantly with increased level of dietary *H. sabdariffa* seed meal above 50% (that is 75% and 100% inclusion level). This might be due to increased level of anti-nutritional factors arising from increased *H. sabdariffa* seed meals in the diets. Raw Roselle meal contains protein inhibitors (trypsin inhibitor) which affect the activity of digestive enzymes thereby causing digestive losses (Faris and Singh, 1990). This might have contributed to the slight decrease in haematological parameters observed in this work. Anti-nutritional factors have been reported to have deleterious effects and can interfere with food utilization, health and production of fish (Makkar, 2003; Jiraungkoorskul *et al.*, 2003). Lieiner (2014), recorded that protease inhibitors including trypsin are potential anti-nutrients and are known to reduce growth performance. Sadekarpawar and Patrick (2013) reported that nutritionally deficient diets decrease haemoglobin concentration, reduces haematocrit and red blood cells volume. Khajepour *et al.* (2011), found that nutritional toxicity is associated with anaemia in fish which is caused by shrunk red blood cell a situation that can result in fish asphyxiation and death. Osuigwe *et al.* (2003) corroborated with this study by attributing the low values of Hb. PCV and RBC in *Clarias gariepinus* to raw Jack bean seed meal which had anti-nutritional factors inherent in the plant protein. The findings of this study also agree with earlier reports (Lin and Luo, 2011;). Fish fed diets 1, 2 and 3 which had (0%, 25% and 50% respectively) *H. sabdariffa* seed meal however recorded a high level of Hb concentration, PCV and RBC counts. This is to say that fish fed 100% fishmeal, 75% and 50% of fishmeal conferred better haematological profile in *O. niloticus* than those fed only 25% and 0% fishmeal. This corroborated with the findings of Jahan *et al.* (2007) in their work on partial replacement of fish meal protein by soybean meal protein in the diet of mrigal, (*Cirinus cirrhosis* Ham). in their study diet 3 (which had 50% fishmeal and 50% soybean (*Glycine max*) seed meal performed better and had the highest haematological profile.

CONCLUSION.

The result of the experiment revealed that 50% inclusion level in the practical diet of *Oreochromis niloticus* was the best and does not have any detrimental effect on the haematological parameters of the fish under study.

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Growth performance of African Cat fish (*Clarias gariepinus*, Burchell 1822) fed with different commercial fish feeds in Borno State

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ASBTRACT

Studies on the growth performance of *Clarias gariepinus* fed with different commercial fish feeds found in Maiduguri Metropolitan was studied in the Department of Fisheries, University of Maiduguri between July and August, 2021. The aim was to assess the effect of the different feeds on the growth of *Clarias gariepinus*. Two hundred and fifty fingerlings were obtained from a reputable fish farm in Borno State and were transported to the Department of Fisheries where they were acclimatized for three days. Ten fingerlings were stocked in each tank having the total of eight experimental tanks with three replications. Each of the fingerlings were weighed in grammes and length measured in millimetres before stocking. Water quality parameters such as temperature, pH and dissolved oxygen were monitored and measured throughout the experiment. The fingerlings were fed 5% of their body weight for a period of one month. Measurement of their weight in grams, total length and standard length in millimetres were made at the end of every week for a period of 30 days. The data collected were analysed using descriptive statistics, some standard formula and one-way analysis of variance. The results showed that the highest mean weight gain was multifeed with 44.1g and followed closely by coppens with 41.4g. Sarbgeher brand was third with 37.8g. Water quality parameters monitored were temperature, dissolved oxygen and pH and they were all within the required range for culturing of cat fish. The results of the analysis of variance revealed that all the feeds were statistically different at $P < 0.05$ with multifeed having the best growth performance. This implies that multifeeds was good for culturing of catfish and therefore it is recommended for fish farmers to use for culturing their fish.

Keywords:

Introduction

Fish feeds are used in aquaculture to increase production and maximize profit. Feeds in intensive fish culture consume about 60% of the capital cost (Eyo, 2001). For aquaculture to be highly successful in Nigeria there is need for good quality and cheap feed, which can also encourage small scale farmers in the field of aquaculture for sustainable production and also meet the demand of fish. In Nigeria, there are different fish feeds with different compositions. The culture of fish is receiving a lot of attention in Nigeria with the result that new cultivation techniques are being introduced and adopted. Over the last decade, spectacular growth has taken place in aquaculture in Nigeria. Fish farming activity in Nigeria started about 50 years ago (Olagunju *et al.*, 2007) and as now aquaculture in the country is in the development stage, because it has not been able to meet the demand of the ever increasing population (Ojutiku, 2008).

Fish farming has generated a lot of interest in Nigeria in the last decade, and many investors have rushed into commercial fish farming with the aim of maximizing profit on investment (Bamidele, 2007). However, only very few have succeeded and many others have abandoned their farm due to different problems ranging from technical to management problems (Kamar, 2006). Falaye (2003) reported that good quality fish (Juvinales) and unavailability of suitable artificial feed formulated locally are among the problems facing successful aquaculture in Nigeria and currently the high cost of feeds and the raw materials for making the feeds.

Justification of the study

No studies were carried out on the performance of all the fish feeds in Borno State

Objectives of the study

- i. To determine the growth performance of all the fish feeds in Borno State on *Clarias gariepinus*
- ii. To determine some of the physico-chemical parameters of the water during the experiment

Materials and Methods

Study Area

Maiduguri also known as “Yerwa” by its locals is the largest capital and the longest city of Borno State in the North-Eastern Nigeria. It is popularly called “Home of Peace”. It has an area of

868km² and a population of 211, 204 at the 2006 census. The city sits along the seasonal Ngadda River which disappears into the firkin swamps in the areas around Lake Chad. Maiduguri was founded in 1907 as a military outpost by the British and has since grown rapidly with a population exceeding one million. The region was home to Kanem-Borno Empire for centuries. Maiduguri actually consist of two cities; Yerwa to the west and Maiduguri to the East. Old Maiduguri was selected at approximately the same time by alongside Shehu Garbai of Borno to replace Kukawa as the new traditional capital of the Kanuri people. Maiduguri Metropolitan Council is on Longitude 11°30'N 13°00'E Coordinates: Latitude 11°30'N 13°00'E. Maiduguri is estimated to have a population of 1, 197, 497 (2006, census) cited by GeoNames geographical database. Its' resident are most Muslims including Kanuri, Hausa, Shuwa, Bura, Marghi and Fulani ethnic groups. There is also considerable Christian population. According to the 2006 population census, Maiduguri has the total number of 1, 112, 449 people (Geo Names geographical database).

Materials List and Method or procedure for the experiment

The materials used were Experimental tanks, Fish i.e. *Clarias gariepinus*, Commercial Fish feeds, Sensitive electrical weighing scale, Measuring board, Mercury in glass thermometer, Dissolve oxygen analyser, PH meter, Towels, Plastic container. Commercial fish feeds were obtained from reputable fish feeds sellers in Maiduguri Metropolitan area of Borno State. A total of 8 different feeds were obtained and labelled A to H. The *Clarias gariepinus* fingerlings' used were obtained from a reputable fish farmer in Maiduguri Metropolitan, Borno State. The *Clarias gariepinus* were acclimatized and stocked at 10 fish per square meter of 2m x 2m experimental tanks at department of fisheries, University of Maiduguri. Before stocking. The total weight in grams and length of the fish in millimetres were measured using top loading sensitive electrical weighing scale and measuring board respectively. Fish in all experimental tanks were fed 5% of their body weight three times daily, morning by 8:00am, afternoon by 2.p.m and evening by 5:00pm for 30 days between the months of July and August, 2021. Measurement of lengths and weight of the fish in each tank were weekly for the period of four weeks. Fish total weight per experiment, weight per fish, total length of each fish, standard length of each fish, final weight, fish mortality, and total feeds consumed per experiment were recorded. Water parameter such as temperature, pH water level and dissolved oxygen (DO) were maintained. The temperature was recorded using mercury in glass thermometer. DO was recorded using dissolved oxygen analyser and hydrogen ion concentration using pH meter

Data collection

At the end of experiment, weight gained and daily average growth rate (ADG), specific growth rate (SGR), food conversion rate (FCR), and protein efficiency rate (PER) were calculated using the formula (Odedey, 2007)

$$ADG = \frac{[L_2 - L_1]}{t}$$

Where L_2 = Final weight of fish (g)

L_1 = Initial weight of fish (g)

t = Rearing period (days)

$$SGR = \frac{(\log w_2 - \log w_1) \times 100}{T}$$

where = $\log w_2$ = Log of final weight (g), $\log w_1$ = Log of initial weight (g), t = Rearing period (days)

$FCR = F(W_1 - W_0)$ Where F = the weight of feed supply of fish during study period, W_0 = the live weight of fish at the beginning of the study

W_1 = the live weight of fish at the end of the study

Data Analysis Data obtained were subjected to analysis of variance. (ANOVA) and means were separated using the least square difference (LSD) at 95% level of confidence, all in Statistix 13.0 version

Results

Water Quality Parameters

The monitored water quality parameters temperature, pH and dissolved oxygen as shown in table 1. The result showed that Temperature for each of the treatment A to H in all the treatments there were not significantly different ($p>0.05$) from each other. However, the least temperature, pH and dissolved oxygen were 25.93°C, 6.61 and 6.10mg/l respectively while the highest were 27.4°C, 7.70 and 7.50mg/l respectively. For the mean separation, all the means having the same superscript in column did not show significant statistical difference.

Table 1: Some mean water quality parameter during the experiment

Treatment	T°C	pH	DO(mg/l)
T _A	26.13±0.05	7.15±0.02	6.50±0.01
T _B	26.52±0.0	7.43±0.05	7.30±0.03
T _C	25.93±0.03	6.61±0.03	7.40±0.02
T _D	26.32±0.01	7.02±0.04	6.10±0.05
T _E	27.11±0.06	7.70±0.07	7.40±0.03
T _F	27.43±0.05	7.10±0.03	6.60±0.06
T _G	26.51±0.03	7.55±0.03	7.50±0.02
T _H	26.64±0.04	7.4±0.05	7.50±0.03

Key: A=local feed 1, B= local feed 2, C= commercial feed 2, D= commercial feed2, E=commercial feed 3, F=commercial feed 4, G= commercial feed 5, and H= commercial feed 6,

Growth performances and Survival of *Clarias gariepinus* fed with eight (8) different

Local and foreign feeds

The growth performance of *Clarias gariepinus* in all the eight (8) treatments are shown in table 4.2 below. The mean weight gains during the study for feeds A to Feed H were 5.9, 7.6, 37.8, 44.1, 41.4, 37.4, 4.2, and 12.2 respectively. Feed D had the highest mean weight gain of 44.1 closely followed by feed E with means weight of 41.4 and feed E with mean with gain of 37.8 while feed F had mean weight gain of 37.4. Others parameters calculated were mean total and standard length, condition factor, survival rate, specific growth rate, coefficient of correlation and the slope (intercept) and are presented in table 2.

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Table 2: Growth and Survival of *Clarias gariepinus* fed with different local and foreign feeds within the experimental period.

Mean value	A	B	C	D	E	F	G	H
Initial number of fish	10.000 ^a	10.000 ^a	10.000 ^a	10.000 ^a	10.000 ^a	10.000 ^a	10.000 ^a	10.000 ^a
Final fish number	2.000 ^a	2.000 ^a	9.000 ^b	9.000 ^b	9.000 ^b	10.000 ^a	6.000 ^c	2.000 ^a
Survival rate (%)	2.000 ^a	2.000 ^a	9.000 ^b	9.000 ^b	9.000 ^b	10.000 ^a	6.000 ^c	2.000 ^a
Mean initial weight(kg)	13.500 ^a	13.600 ^a	13.700 ^a	13.800 ^a	13.800 ^a	13.500 ^a	13.900 ^a	13.800 ^a
Mean final weight (g)	19.400 ^a	21.200 ^a	51.500 ^b	57.900 ^b	55.200 ^b	50.900 ^b	18.100 ^a	26.000 ^c
Mean weight gain (g)	5.900 ^a	7.600 ^a	37.800 ^b	44.00 ^b	41.400 ^b	37.400 ^b	4.200 ^c	12.200 ^c
Mean initial total length	137.500 ^a	132.500 ^b	132.300 ^b	133.000 ^b	133.100 ^b	131.900 ^b	131.600 ^b	132.00 ^b
Mean final total length	149.500 ^a	152.500 ^a	192.000 ^b	203.800 ^b	200.00 ^b	196.400 ^b	142.800 ^a	57.500 ^c
Mean total length gain	12.000 ^a	20.000 ^a	59.700 ^b	70.800 ^b	66.900 ^b	67.500 ^b	11.200 ^a	20.500 ^c
Mean initial standard length	122.000 ^a	116.500 ^b	122.800 ^a	117.300 ^b	115.100 ^b	111.700 ^b	115.00 ^b	110.500 ^b
Mean final standard length	130.000 ^a	132.500 ^a	173.000 ^a	180.000 ^b	177.900 ^c	173.500 ^b	125.700 ^c	140.000 ^a
Mean standard length gain	8.0000 ^a	16.000 ^c	50.2000 ^b	62.700 ^b	62.800 ^b	61.800 ^b	10.700 ^c	9.500 ^a
Specific growth rate	19.700 ^a	25.300 ^a	126.00 ^b	147.00 ^b	138.00 ^b	124.7.00 ^b	14.00 ^c	40.7.00 ^a
Exponential (slope) values (b)	0.950 ^a	0.925 ^a	3.000 ^b	3.0100 ^b	2.866 ^b	2.238 ^b	1.714 ^c	0.962 ^a
Condition factor (k)	1.310 ^a	1.030 ^a	1.900 ^a	2.010 ^b	1.750 ^a	2.000 ^b	1.2000 ^a	1.300 ^a
Coefficient of correlation (r)	1.000 ^a	1.000 ^a	0.9217 ^b	0.5696 ^b	0.8554 ^b	0.9718 ^b	0.884 ^b	1.000 ^a

Mean values having the same superscripts are not significantly difference in each row ($P \geq 0.05$) except those with different superscript. ($P \leq 0.05$)

Key: T_A=local feed 1, T_B=local feeds 2, T_C= commercial feed 1, T_D= commercial feed 2, T_E= commercial feed 3, T_F= commercial feed 4, T_G= commercial feed 5, and T_H= commercial feed 6.

Table 3 Shows food conversion ratio (FCR)

Treatment	FCR
T _A	2.8
T _B	2.9
T _C	1.6
T _D	1.3
T _E	1.5
TF	2.0
T _G	1.9
T _H	1.8

Discussion, Conclusion and Recommendation

Discussion

The water quality parameters of the whole pond during throughout the experiment only showed little variation but there were no significant statistical differences. The range of temperature (25.93°C-27.4°C), pH (6.61-7.7) and dissolved oxygen (6.10mg/l-7.50mg/l) obtained were favourable for fish culture of *Clarias gariepinus*, they were within the range described as optimal by Boyd (1979) and this agrees with similar work carried out by Balogun *et al.*, 2004 and Auta *et al.* (2013). The Similar results of insignificant difference were recorded for Carbon dioxide, Total alkalinity, dissolved Oxygen and pH throughout the period of the experiment. Results of each treatment were not altered by water parameters in this experiment as they were not significantly different in the treatments. The average temperature, dissolved oxygen, total alkalinity and carbon dioxide for the various treatment observed also showed just little variation as reported by Adewumi(2009). For the performance of the feeds in this study, Commercial feed 2 gave the highest mean weight gain of 44.1 followed by Commercial feed 3 with 41.4 and Commercial feed 1 with 37.8. The high growth rate recorded in fingerlings fed commercial feed 2 and 3 may be attributed to the high nutritive value of the feeds and tolerable physico-chemical parameters against the lesser values in feed 2 and Aquaplus which could be due to the anti-nutritive elements present in the feeds, this is also in line with Dada and Gnanados, 1983 who obtained high values for feeds 2 and 3. The growth of fish depends upon the ingredients and its percentage in the formulated feed (Glencross *et al.*, 2007). The results also compared well with comparative feed trials of Rahman *et al.* (1997) and Henken *et al.* (1986) who recorded best growth results for feed containing 40% and 58% CP respectively in *Clarias* spp. The results agree with that of Giri *et al.* (2003) who reported an increase in body weight gain and SGR in post larvae of *Clarias hybrid* fed increased level of protein.

Conclusion

By considering the results of the study, the water quality parameters were properly monitored and they were within the required range. Temperature 24°C -31°C, range (25.93°C-27.4°C)PH6.5-8.5, Range (6.61-7.7), dissolved oxygen 5mg/l-8.5mg/l, range (6.10mg/l-7.50mg/l). Commercial feed 2, Commercial feed 3 and Commercial feed 1 were the best feeds that supported the growth of *Clarias gariepinus* cultured in concrete tanks. Economically Commercial feed4 also performed well and is the cheapest in terms of price as such its preferred for most optimal growth and cost benefits.

Recommendation

Based on the findings of this study, the feeds that gave the best mean weight gain on *Clarias gariepinus* are highly recommended to fish farmers in culturing *Claria gariepinus*. These recommended feeds are Commercial feed 2, Commercial feed 3 and Commercial feed 1. Also further investigation should

be carried out on other fish species under different culture conditions either in earthen and Polyethane lined fish pond.

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FISH AND ENVIRONMENTAL TOXICOLOGY

TISSUES-SPECIFIC BIOACCUMULATION OF HEXACHLOROCYCLOHEXANES IN *ALESTES NURSE* AND *CHRYSICHTHYS NIGRODIGITATUS* FROM A NEWLY FORMED TROPICAL RESERVOIR: A CASE STUDY OF BUI, GHANA

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ABSTRACT

Tissues distribution of HCHs in *A. nurse* and *C. nigrodigitatus* from Bui Reservoir were analysed from January to December 2018. GC-ECD was used to identify and quantify the residues in the tissues. Four HCHs were detected in the tissues of both fish and their mean concentrations range from $0.54 \pm 0.24 - 156.55 \pm 37.65$ ng/g-ww (wet weight) in muscles and gonads of *A. nurse* and from $0.55 \pm 0.13 - 347.48 \pm 23.49$ ng/g ww in muscles and gonads of *C. nigrodigitatus*. α -HCH and γ -HCH dominated in *A. nurse* and *C. nigrodigitatus* respectively. Statistical analyses did not show significant difference ($p > 0.05$) in HCH concentrations among tissues. The results have shown that in terms of monitoring HCH in the Reservoir, use of muscle tissues will be adequate and representative.

Key words: *Alestes nurse*. *Chrysichthys nigrodigitatus*, Concentration; Gonad; Muscle; Reservoir

Introduction

Pesticides are used to kill agricultural pests, however, not up to 0.3% of the applied pesticides get to the target organisms (Tombesi *et al.*, 2018). Hexachlorocyclohexanes (HCHs) are a group of organochlorine pesticides (OCPs) which were ban due to their impact on non-target organisms and human health implications (Harris and Smith 2016). However they are still illegally use by peasant farmers in developing countries because of their perceived effectiveness and low cost (Darko *et al.*, 2008). Aquatic ecosystems located adjacent to agricultural area receive pesticides runoff after rainfall or irrigation events which present a significant risk to the resident aquatic biota. The hydrophobic and lipophilic nature of the pollutants facilitate their incorporation into the food chain which leads to contamination of public food supply such as fish (Darko *et al.*, 2008). Since wild fish are exposed to the pollutants during their entire life cycle, they are susceptible to accumulating these pollutants in their tissues (Schilderman *et al.*, 1999). Fish are among the group of aquatic organisms that represent the largest and most diverse group of vertebrates (Yancheva *et al.*, 2015). Consequently, it becomes imperative to measure the contaminant concentrations in some common edible fish species of Bui Reservoir for both ecological and human health perspectives. *A. nurse* and *C. nigrodigitatus* are commercially important and widely distributed species in Bui Reservoir (Alhassan, 2013). Contaminants in fish are measured in different tissues as tissue type is known to have a substantial effect on the level of uptake of lipophilic pollutants (Zhoa *et al.*, 2014).

Bui Reservoir is still very young (about 9 years) compared with most reservoirs in Ghana that are currently considered old (>50 years) and in a stable state in terms of their characteristics and services provision. However, no data is available with respect to HCH concentrations in fish from the Reservoir in spite of its' importance as a major source of fish protein to large communities across the country and beyond (Alhassan, 2013). This study seeks to provide information on the bioaccumulation of HCHs in some tissues of *A. nurse* and *C. nigrodigitatus* of the Bui Reservoir, especially as the irrigated agriculture intensifies in the area with a resultant increase in pesticides uses and transport.

Materials and Methods

Fish and Tissues Sampling Protocols

Fish samples were obtained from fishermen's catch at the fish landing site of the Reservoir on quarterly basis from January – December 2018. A total of 24 fish 12 each for *A. nurse* and *C. nigrodigitatus* were sampled during each sampling day. The fish were identified using key identification according to Holden and Reed (1972). Samples were store in ice-box, transported to the laboratory and refrigerated as described by EC (2010). At the laboratory, fish were gutted and the tissues of interest harvested. Individual tissues from each fish species were bulked and encased in aluminum foil wrapper and separately placed in a labeled plastic bag for extraction (Rosseland *et al.*, 2001).

Extraction, Concentration, Clean-up and quantification of Analytes

Ten (10 g) of fish tissues (gills, gonads, intestines and muscles) was spiked with 1 μ L of the mixed HCH standards and then ground with 15 g of Na_2SO_4 and transferred into a sonicating jar. Then 100 mL n-hexane/acetone (3:1 v/v) mixtures was added to the jar containing the homogenized tissue sample and extraction was carried out at 45°C in an ultrasonic bath. The mixture was then poured into a flask container through a filter paper held in a funnel. The extraction and concentration were done as described by US EPA Method 3550C, 2000 and US EPA Method 3570C, 2002 respectively. The collected eluate was clean-up and re-constituted in 2 mL ethyl acetate and the final digest was introduced into a 2 mL vial for subsequent evaluation (US EPA method 3630B, 1996). The quantification of analytes were executed by introducing 1 μ L cleaned analytes into the injector pot of a gas chromatograph with a ^{63}Ni electron capture detector fitted with a ChemStation software.

Statistical Analyses

One-way ANOVA was used to evaluate the distribution of HCHs in the tissues of the fish samples. Statistical analyses were performed at an alpha value ($\alpha = 0.05$).

Results and Discussion

Tables 1 and 2 show the mean concentrations of HCHs in the various tissues of the two fish species studied. There was no significance difference ($p > 0.05$) in tissues bioaccumulation of HCHs in both fishes. However, α -HCH dominated in the gonads (156.55 ± 37.65 ng/g-ww) and muscles (117.73 ± 2.42 ng/g-ww) while β -HCH and γ -HCH were the dominant isomers in the gills (36.60 ± 6.00 ng/g-ww) and intestines (156.24 ± 3.88 ng/g-ww) of *A. nurse*. In *C. nigrodigitatus* the highest mean concentrations of the α -HCH were recorded in the muscles (145.55 ± 94.66 ng/g-ww), intestines (76.66 ± 4.16 ng/g-ww), gills (34.17 ± 22.92 ng/g-ww), and while γ -HCH dominated in the gonads (347.48 ± 23.49 ng/g-ww). The dominance of α -HCH in most of the tissues of the fishes suggest that the source of the contaminant was technical mixture of HCHs. Technical HCH contains 60 – 70 % α -HCH, 5 – 12 % β -HCH, 10 – 15 % γ -HCH and 6 – 10 % δ -HCH (Sun *et al.*, 2010). It could also be attributed to the transformation of the γ -isomer to α -isomer in these tissues (Zhao *et al.*, 2014). The predominance of the γ -HCH in the intestines of *A. nurse* and the gonads of *C. nigrodigitatus* indicate recent input of purified HCH (Lindane) this is further confirmed as the ratio of α/γ -HCH < 1 (Law *et al.*, 2001). Omwenga *et al.* (2016) in a similar study of OCPs accumulation in some tissues of *Oreochromis niloticus* from Kiambu fish farm, Kenya, reported high concentrations of γ -HCH in the liver, muscle, gonad and brain. β -isomer preponderance in the intestines of *A. nurse* indicates effective degradation of the compound to the more stable metabolite and may further indicate previous input of HCHs from the watershed.

Table 1: Mean concentrations (ng/g-ww) of HCHs detected in the tissues of *Alestes nurse* of Bui Reservoir (n=2) from January to December, 2018

Isomer	Gill	Gonad	Intestine	Muscle
α -HCH	5.28 ± 3.82^a	156.55 ± 37.65^a	4.65 ± 0.75^a	117.73 ± 2.42^a
β -HCH	4.07 ± 0.64^a	18.05 ± 15.55^a	36.60 ± 6.00^a	0.54 ± 0.24^a
γ -HCH	44.96 ± 0.55^a	29.45 ± 14.95^a	156.24 ± 3.88^a	12.64 ± 1.01^a
δ -HCH	3.56 ± 1.56^a	3.5 ± 0.15^a	2.7 ± 0.17^a	BDL ^a

There were no significant differences ($p > 0.05$) in the mean concentrations of HCHs across the row

BDL (Below Detection Limit) = < 0.1

Table 2: Mean concentrations (ng/g-ww) of HCHs detected in the tissues of *Chrysichthys nigrodigitatus* of Bui Reservoir (n=2) from January to December, 2018

Isomer	Gill	Gonad	Intestine	Muscle
α -HCH	34.17 ± 22.92^a	28.94 ± 28.94^a	76.66 ± 4.16^a	145.55 ± 94.66^a
β -HCH	0.74 ± 0.04^a	2.39 ± 1.03^a	3.1 ± 0.50^a	0.55 ± 0.13^a
γ -HCH	18.23 ± 0.19^a	347.48 ± 23.49^a	5.18 ± 0.41^a	2.11 ± 0.04^a
δ -HCH	0.61 ± 0.11^a	BDL ^a	2.09 ± 0.10^a	3.24 ± 3.24^a

There were no significant differences ($p > 0.05$) in the mean concentrations of HCHs across the row

BDL (Below Detection Limit) = < 0.1

CONCLUSIONS

The no difference in HCH concentrations among tissues of *A. nurse* and *C. nigrodigitatus* implies that in terms of monitoring HCH in the Reservoir, the use of muscle tissues will be adequate and representative.

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TRACE ELEMENT BIOACCUMULATION IN FISH AND HUMAN HEALTH IMPACT: A REVIEW

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ABSTRACT

Trace metals occur during natural processes and also obtained during anthropogenic activities. Trace metals include chromium, cadmium, arsenic, lead, zinc, nickel, mercury, selenium and copper hence their presence in the aquatic habitat are highly toxic to fishes and shell fishes. In the ecosystem, trace metals are found in the aquatic environment from contamination by deposits of trace metals from industrial, agricultural waste and by-products and domestic waste and by products. The increasing level of trace metals in fish is alarming and has spurred scientists to make researches on the dangers caused by the trace metals resulting to trace metal accumulation and bioaccumulation of life cells. This study aims at assessing the possible sources of trace metal in the aquatic environment, impact of Trace metals in aquatic environment, its bioaccumulation in fish and human health impact, Irritation of the gastrointestinal mucosa, nephritis, necrosis, neurological

and behavioral disorders and death amongst others). In conclusion, negative results of the presence of trace metals and the effects of bioaccumulation and bio-magnification have been reviewed in this paper. This study recommends that the proper assessment and treatments of all forms of wastewaters, agricultural waste, sewage, industrial effluents be carried out before their discharge into the environment.

Keywords: Bioaccumulation, Death, Environment, Health status, Natural pollution, Toxic effect

Introduction:

Trace metals (TM) are metals which have a density of above $5\text{mg}\cdot\text{cm}^{-3}$ and negatively affect life in any form. They are harmful when they exceed threshold limits (WHO 2020). TM occur during natural processes such as erosion, volcanism and weathering. TM are also obtained during anthropogenic activities that takes place in the; industry, mining, metal smelting, oil refining, agriculture and fertilization and drainage (Wei *et al.*, 2018). Trace metals are easily accumulated in fishes because they are readily taken up by body parts of fishes such as body surface, gills, digestive tract, liver and muscles. The highest point of TM levels of concentration in the organs of organisms are often the gills then the liver and then the muscle shows the lowest concentration levels. However, the muscles are the most source of Trace metal intake to the body since the muscles are the largest consumed parts of the body hence the ability to cause negative impact towards health. Caution must be taken to assess the levels of Trace metals for consumption (WHO 2020)

This study aims at assessing the possible sources of trace metal in the aquatic environment, impact of trace metals in aquatic environment, the results of such accumulation of TM (bioaccumulation) and the resulting impact on human health.

Materials and method:

This paper reviews the effects bioaccumulation of trace metals in fish and humans. Information used was obtained from results and reports from various authors and the findings from already published papers are carefully assessed. Efforts were made to emphasize the various reasons responsible for the observed results.

Results:

Trace metals become available in the environment from various sources and processes:

Natural processes: Research has revealed that under specific environmental conditions and numerous processes, trace metals are released naturally in the environment. Such of processes include erosion, volcanic eruption, weathering, rock weathering, sea-salt sprays, forest fires, biogenic sources and wind-borne soil particles. During natural weathering, heavy metals in the form of hydroxides, oxides, sulphides, sulphates, phosphates, silicates and organic compounds of varying amounts are deposited in the environment (Wei *et al.*, 2018). These TMs are substances that occur naturally in the environment but in trace amounts with no important biological role to play in human existence; causing many toxic effects that lead to malfunctioning of the body systems and disruption of metabolic process.

Anthropogenic processes: Industries, aqua cultural and agricultural practices, wastewater, mining and metallurgical processes, and runoffs also lead to the release of pollutants to different environmental compartments. Anthropogenic processes of heavy metals is recorded to go beyond natural fluxes for some metals. HMs from industrial activities and location are equally blown as dust by wind, some are emitted from the combustion of Hydrocarbons and released as automobile exhaust to release lead; smelting releases smelting which releases arsenic, copper and zinc; insecticides which release arsenic and burning of fossil fuels which release nickel, vanadium, mercury, selenium and tin. Human activities have been found to contribute more to environmental pollution due to the everyday manufacturing of goods to meet the demands of the large population

Trace metals are introduced into the aquatic environment by activities from the use of:

Agricultural sector

Pesticides

Pesticides are all chemicals and substances that are used to kill or control pest and diseases. Other agrochemicals used includes herbicides (weed), insecticides (insects), rodenticides (rodents), fungicides (fungi), nematocides (nematodes) or in disease control programs to safe guard humans from vectors-borne

diseases. In addition to the aforementioned are; pet shampoos, skin care and tick sprays for livestock . Pesticides contain numerous chemical composition characteristics such as organochlorines, organophosphorus (OPs), carbonates, pyrethroids, neonicotinoids and sulfanilic, carbamic acid, phenylpyrazole, pyridium, isoxazolyl urea, benzothiazolyl urea[WHO 2020]. Pesticide toxicity is the capability of pesticide to cause injury to an organism. Exposure to pesticide is hazardous to the behaviour and well-being of humans and animal life which are often linked to a wide range of diseases. Pesticides are classified according to the pest they kill The classification is based on the physical and chemical characteristics they possess. Such information is beneficial for determining the application method, rate, and the precautions that need to be considered during the application. Within each class, there are many subclasses to expose the chemical content and examples of such pesticides.

The popularly known dichloro-diphenyl-trichloroethane (DDT) and lindane (HCH) were widely used in the 1950s-1970s to control pests but due to its high environmental persistence and potential for long atmospheric transport the (Authman *et al.*, 2013a) had to advise against the use of such of this organochloride. Pesticides are also organic micro pollutants that have ecological impact when introduced into agriculture to enhance and promote the production of food and produce. These Trace pesticides often get into water bodies and cause adverse effect to the life it inhabits and the environment.

The high rise in pesticides concentration and deposition in the environment causing pollution is often attributed to the rapid urbanization, industrialization, economic growth, and development of dynamic agricultural practices, increased human and domestic activities.

Fertilizers

Fertilizers are chemical substances with essential nutrients used by farmers and provided to crops to boost productivity. The essential nutrients include nitrogen, potassium, and phosphorus.

Industrial sector

Geo-mining (quarry, blasting, crude oil mining)

The introduction of Trace metal into water bodies can be through natural occurrences such as volcanic eruption, land slide and anthropogenic activities like all forms of mining, crude oil spills, pipe line vandalism, illegal bunkering of crude oil, and HM from untreated effluents. Heavy metals from such polluted sites are introduced directly through surface run off into water bodies or indirectly through non-point source contaminants washed into water bodies (Authman *et al.*, 2013b).

Domestic waste (wastewater)

Processed water from cosmetic industries, detergent industries, textile industries often contain high levels of HM. The release of such waste into surrounding water bodies can lead to the destabilization of ecological stability organisms.

The presence and load of heavy metals is reported to be most at the gills, liver and least in the flesh. In the common carp *Cyprinus carpio*, it was observed that Cd and Pb were most deposited at such organs respectively which is an indication of bioaccumulation (WHO 2020).

Effects of trace metal in fish and man

Chromium (Cr) in fish

Chromium is reported to have lesser accumulation on fish muscles compared to fish gills. Chromium shows poisonous effect in the blood such as anemia, eosinophilia and lymphocytosis, branchial and renal lesions. The EPA recommend that levels from 50 to 100ugCr·L⁻¹ can be permissible for the management of aquatic life and safe guarding human health (WHO 2020).

Chromium in man

Workers in the textile and steel industries are often affected by Cr (IV) which is harmful to human health. Other health issues are seen in tobacco smokers who are often exposed to high doses of it. Leather products from chromium are likely to cause allergies on the skin in the form of rashes, the nose is easily irritated and in extreme cases the nose bleeds. In addition, the immune system is lowered, diseases of the skin, Irritation of the gastrointestinal mucosa, Nephritis, Lung cancer, liver and kidney damage, Necrosis, death in man .

Mercury (Hg) in fish

Mercury is taken up during ingestion and passed on the liver where its action is distributed. Mercury is one of the TM most toxic to fishes. In the liver, it binds, stores, and redistributes the mercury through surface circulation into various tissues and organs such as the gill tissues, liver and mostly the kidney. In these tissues and organs the TM are often accumulated over time hence bioaccumulation.

The toxicity of Mercury is accompanied by convulsions and ataxia, detachment of gills, fusion of secondary gill filaments, inflammation and deterioration of the liver and blood vessels. Low levels Hg in the reproductive system in Zebra fish, *Gynotus carapo* affect the production and viability of the ovaries, eggs, sperms and survival of fry (WHO 2020).

Mercury (Hg) in man

Low concentration of mercury even when trapped in vapours can lead to nervous disorders leading to total change of behaviour in man such as tremors, emotional instability, insomnia, memory loss, ulcers and cancers in the thyroid and kidneys. Mercury is poisonous causing mutagenic effects, disturbs the cholesterol levels and high exposures can lead to death (greenfacts.org).

Lead (Pb) in fish

- Pb is a hazardous substance commonly characterized as a persistent Trace metal. It is a substance that occurs naturally in the environment. However, its deposition are accumulated by increased activities of man such as mining of base metals, manufacturing of all sorts of batteries, lead-based paints and lead-fuels (Auta *et al.*, 2005). Lead finds its way into water from run-offs and discharge from industries, from the dissolution of old lead plumbing, lead containing pesticides, through precipitation, fallout of lead dust, street runoff, and municipal wastewater. Pb as a potent environmental pollutant affects the trophic levels in a food chain. Pb from system run offs, industrial and sewage waste and are taken up by fish through ingestion and inhalation from aquatic medium. High doses results in metabolic poisoning, irritability, anemia as well as behavioural changes.

Lead (Pb) in man

Man can be affected by Pb through inhalations, from food intake which are then accumulated in the muscles, bones, blood and fat. These accumulations damages various organs and tissues in the body. Lead is reported to affect Newborns and young children even at low levels (Mensoor and Said 2018).

Pb is known to cause reproductive disorders osteoporosis (brittle bone disease) heart disease, high blood pressure, especially in men, anemia, psychological disorders and IQ (Mensoor and Said 2018).

Arsenic (As) in fish

Arsenic is a substance used in the agricultural sector for the production of pesticides and defoliants. It is significantly used to reduce and kill aquatic weeds that disrupt fishing areas [Mensoor and Said 2018]. Just like other HM, Arsenic has the capacity to be stored in large quantities in water and in an organism especially aquatic organisms [Mensoor and Said 2018]. Arsenic toxicity causes histopathological changes and defects in internal organs such as gills, kidneys, liver bile duct proliferation and parenchymal hepatocytosis (Figure 2). Apoptosis of the heart muscles, enlargement of intestinal mucosa and submucosa, acute exposures can lead to death (Mensoor and Said 2018).

Arsenic (As) in man

The ingestion of high levels of inorganic arsenic causes negative effects to the human system. Some of such effects include skin diseases and cancers, reproductive effects, diseases of the lungs, liver, kidney and bladder, non-insulin dependent diabetes mellitus and visual impairment in children (Mensoor and Said 2018).

Cadmium (Cd) in fish

Increased industrial activities in the 20th, and 21st century has led to enormous production, consumption, and release of cadmium. Such cadmium is often produced for industrial uses such as manufacturing of batteries, electroplating, plastic stabilizers, pigments and fertilizers, agricultural chemicals, pesticides. Also from sewage sludge then into farm lands that often run-off into groundwater and surface water, might also contribute to the contamination of aquatic habitat causing damage to fish tissues and organs hence fishes through bioaccumulation. (Mensoor and Said 2018). have reported anatomical and structural deformations in the liver of *Cyprinus carpio*, *Carassius auratus* and *Corydoras paleatus*. It was stated that cadmium caused noticeable wounds, discoloration and hardening of the liver.

Cadmium (Cd) in man

Cadmium is a deleterious trace metal and a byproduct of Zinc production. It has an instant destructive impact on humans. Respiratory tract diseases and kidney problems resulting to kidney failure are the commonest diseases gotten from inhalation of cadmium dust. Compounds containing cadmium are carcinogenic thus easily causing cancer, it also causes weakening and total damage to bones. A significant amount has to be ingested to cause immediate poisoning and damage to the liver and kidney (Mensoor and Said 2018).

Aluminum (Al) in fish

Aluminum in water makes the water acidic which is toxic to fish life. The major organ of target is the gill where it mainly disrupts the lamellar epithelial cells and the gill epithelium. These aforementioned dysfunctions results in death of cells and consequently death.[Mensoor and Said 2018], reported that physiological and histological alterations are frequently observed in different fish species exposed to Al in addition to an appreciable reduction concentrations as of Al as low as $0.52 \text{ mg}\cdot\text{L}^{-1}$. Some of such alterations are mainly related to cardiovascular, respiratory, reproductive and structural gill damage as well as liver and kidney damage (Authman *et al.*, 2013a).

Aluminum (Al) in man

Al is not easily detected in the human body in trace amounts consequently it is believed that aluminum is rapidly excreted within a short time of uptake from the body. Residual aluminum has been detected in the skeleton, brain and other tissues in the body (Authman *et al.*, 2013a).

Chromium (Cr) in fish

Chromium will find its way into the environment from discharge released pharmaceutical industries, textiles and dyeing industries, discharge from leather tanneries, metal fishing, electroplating, mining, printing and photography and ceramics . Inadequate disposal and proper treatments of such waste and effluents may lead to the presence of Cr (IV) in the immediate surrounding and aquatic environment, where it can cause harm. The physicochemical parameters of a given water body especially surface waters determines the stability of chromium. Fish gills are the easiest point of uptake of Cr thus leading to accumulation in the tissues mainly through the liver and kidney. The concentration found in fish and other aquatic organisms are often higher and at lethal do then leading to the heart which may seriously affect the catabolic, anabolic and physiological activities furthermore, may deter the optimal growth and behavior of fish (Authman *et al.*, 2013a)

Chromium (Cr) in man

Chromium is an essential nutrient metal necessary for metabolism of carbohydrates . Chromium in man causes mucosal irritation, phytotoxic corrosion, irritation of the central nervous system which is followed by depression and in rare cases death (Authman *et al.*, 2013a).

Discussion

In Nigeria, most of our water bodies serve as reservoirs for drinking and domestic uses, making the distribution of Trace metals and pesticides in aqueous phase, suspended particles and sediments unavoidable. These accumulation of pesticides in our water bodies is a major public health concern . In the aquatic environment, organisms are exposed to pesticides through contact with the gills, skin, ingestion or inhalation into the gastrointestinal tract and muscles. Within the fish the TM is either broken down, used up, released or stored. Trace metals are taken up by different fishes in different forms at different rates according to various factors. It could be due to environmental factors (water chemistry, salinity, temperature, and levels of contamination or biological) or biological factors (species, size, gender, sexual maturity, and food source). These TM are transported to human (Wei *et al.*, 2018).

Report has it that ability and capacity of trace metal to be deposited in fish depends the concentration of metal and time of exposure, nature of the water, pH, hardness and alkalinity and dissolved oxygen, sex and age of fish, season and habitat . Trace metals are taken up primarily from the environment through gills, food, and skin, then are carried to organs and tissues.

Small fishes are affected more than larger ones. Again, freshwater fishes are more affected than salt water fishes. Following a comparison in the magnitude of accumulation of trace metals between marine and fresh water fishes, observed that freshwater fishes tend to accumulate trace metals 6 times more in their organ than marine fishes. The reason for such a difference is that fresh water tends to lose salts and gain water as against marine species. Furthermore concentrations of Trace metals are elevated in the wet season in the environment and in fish tissues than in the dry season (Agbugui and Deekae 2013).

Researchers have suggested that carnivorous fish species which are often predatory and are at the highest trophic levels accumulate more Trace metals as against Omnivorous and Herbivorous fish because carnivorous fish, which mainly eat other organisms at the lower trophic levels such as fingerlings, shrimp, crustacean and zooplankton, thus will consume more amount of metals in the body unlike the non-predatory and carnivorous fishes with varying diets of insects, shrimps, small fish, crustacean, algae, plankton and detritus (Agbugui and Deekae 2013). Thus, accumulation of HM in fish may have been due to diversity of feeding habit and behaviour.

The ingestion, absorption and uptake of trace metals in fish is usually toxic and results in harmful damages to the fish and fish life. Since most of the metals taken up are non-biodegradable, such metals are able to bioaccumulate and bio-magnify. Overtime, the accumulated metals affect the growth and development stages of fish from the production of viable eggs, hatchability laval, fingerlings and juvenile life stages. This is so because the early life stages are more sensitive than during maturing and adulthood.

CONCLUSION AND RECOMMENDATIONS

Fish is a delicate route for the transfer of toxic trace metals to man from water. The harmful effect of trace elements are numerous with varying degrees of destruction to human life and health. Since the living organisms can generally not metabolize, trace metals bioaccumulation and bio magnification, consequently it is of important that Trace metals should not be consumed above the limits permissible by Law and Governing bodies. Trace metals can be neurotoxic, carcinogenic teratogenic and mutagenic causing poisoning such of which are vomiting, convulsions, paralysis, ataxia, hemoglobinuria, gastrointestinal disorder, diarrhea, stomatitis, tremor, depression and pneumonia.

It is therefore recommended that the assessment and treatment of all forms of waste from agricultural waste, sewage, industrial effluents be carried out before their discharge in to the environment. Also, the enforcement of all laws, legislations regarding the protection of aquatic life and environment be enforced and sanctions mitted against defaulters.

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BIOSORPTION OF LEAD AND ARSENIC USING *BACILLUS LACUS* AK 74 AND *HERBASPIRILLUM AQUATICUM* IEH 4430 ISOLATES FROM JEBBA LAKE – NIGERIA.

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ABSTRACT

The quality of surface water has been greatly affected with heavy metals due to overexploitation of resources, urbanization and improper waste disposal practices. Thus, the used of inexpensive biosorbent for clean up and remediation of such polluted water body has become very important. Biosorption of lead (Pb) and arsenic (As) using *Bacillus lacus* AK 74 and *Herbaspirillum aquaticum* IEH 4430 was carried out in this study. Percentage removal (% R) of lead (Pb) and arsenic (As) at low concentration (1.0 ppm) by *Bacillus lacus* AK 74 were 99.0 % and 96.0 % respectively. Percentage removal (% R) of these metals (Pb and As) by *Herbaspirillum aquaticum* IEH 4430 were 48.4 % and 75.5 % respectively. *Bacillus lacus* AK 74 based on its high percentage removal of the heavy metals can be used as biosorbent in lead and arsenic polluted water.

KEYWORDS:

Introduction

Biosorption is the use of biological materials as sorbents for sequestration of metal ions from aqueous solutions. This process utilizes inexpensive biomass for selective uptake of toxic heavy metals and is particularly useful for the removal of heavy metal contaminants from water and sediments. Heavy metals have relatively high density of 5 g/cm³ and above which are toxic or poisonous even at low concentration (Alloway and Ayres, 1993; Lenntech, 2004). Potentially toxic metals include: Cadmium, Aluminium, Arsenic, Antimony, Lead and Mercury. Heavy metals bioaccumulate in fish tissues and the accumulation of these heavy metals over time in fish leads to suppression of fish immunity hence allowing normal flora to cause ulceration and possible septicaemia (Mutuku, 2010). Lead and Arsenic damages the gills, liver and spleen of fish thereby causing death.

Various methods have been employed for the treatment of heavy metal-bearing effluents, which usually include precipitation, adsorption, ion exchange, membrane and electrochemical technologies (Wierzb, 2010). However, these techniques are expensive, not environmentally friendly and usually dependent on the concentration of the waste which is ineffective in much diluted solutions (Volesky and Naja, 2007). Of the different biological methods, biosorption has been identified and demonstrated to possess good potential to replace conventional methods such as reverse osmosis, electro dialysis, ultra filtration, ion-exchange and chemical precipitation for the removal of heavy metals (Malik, 2004). Biosorbent behavior for metallic ions is a function of the chemical make-up of the microbial cells of which it consists. Bacteria are the most abundant and versatile microorganisms and constitute a significant fraction of the entire living terrestrial biomass of 10¹⁸g (Mann, 1990). Bacteria are often used as biosorbents because of their small size, ability to grow under controlled conditions and ability to biosorb one or more elements depending on the species. The aim of this study is to determine the potentials of *Bacillus lacus* AK 74 and *Herbaspirillum aquaticum* IEH 4430 in removal of lead (Pb) and arsenic (As) in polluted water.

Materials and Method.

Preparation of Metal Stock Solution

Stock solutions of Pb(NO₃)₂ and As₂O₃ were prepared by dissolving 0.39 g and 0.66 g respectively each in 250 mL of distilled water. The solution was agitated for 15 minutes and allowed to stand for 24 hours in order to obtain complete dissolution of the salt (Abioye *et al.*, 2017). The pH of the solutions was adjusted to 7.0 using NaOH and HCl. Concentrations of 1.0 ppm, 3.0 ppm and 5.0 ppm were serially prepared and determined using atomic absorption spectrophotometer (PG instrument model, AA500 Spectrophotometer, UK).

Biosorption Analysis

Fifty millilitres (50 mL) of nutrient broth was measured into a two hundred and fifty millilitres (250 ml) flask and this was sterilized at 121 °C for 15 minutes and allowed to cool. The pH solution was adjusted to 7.0 using NaOH and HCl. Two millilitres (2 mL) of inoculum of a known bacterial isolate was added to the nutrient broth. A known concentration of heavy metals (Pb, As) stock solution was added to the nutrient broth in the flask. This was incubated at 37 °C and examined at 7 days interval for a period of 28 days, (Abioye *et al.*, 2015). The supernatant and the cells were separated by centrifugation at 4000 revolutions per minutes (rpm) for 25 minutes. Concentration of the heavy metals was determined on the 7th, 14th, 21st and 28th day of incubation using atomic absorption spectrophotometer (PG instrument model, AA500 Spectrophotometer, UK). Environmental factors such as temperature, pH, biomass concentration and metal concentration are very vital in this process.

Analysis of data

Percentage removal (% R) of each heavy metal was calculated using equation 1.

$$(\% R) = \frac{C_1 - C_2}{C_1} \times 100 \dots \dots \dots \text{Equation (1)}$$

Where C₁ = Initial concentration, C₂ = Final concentration, % R = Percentage removal.

Results and Discussion

Biosorption of Heavy Metals by *Bacillus lacus* AK 74

Biosorption of heavy metals by *Bacillus lacus* AK 74 shows that there were significant removal of lead and arsenic (Table 1). Percentage removal followed this order: Pb > As . It was also observed that at lower concentration (1.0 ppm) of heavy metals, percentage removal was higher (99.0 % and 96.0 % respectively) than at higher concentration (5.0 ppm) which was observed to be 74.4 % and 48.2 % respectively. *Bacillus lacus* AK 74 recorded higher percentage removal of lead (99.0 %) when compared to arsenic (96.0 %) at 1.0 ppm. Sarah *et al.* (2021), however revealed that among heavy metals studied (Arsenic, Cadmium, Lead), arsenic is most tolerated by *Bacillus*. Generally it was observed that *Bacillus lacus* AK 74 was a strong biosorbent for lead and arsenic with over 90.0 % removal within 28 days. Hydrolytic enzymes could be secreted by *Bacillus* species, which are capable of tolerating heavy metals (Abioye *et al.*, 2018). *Bacillus lacus* AK 74 was seen to effectively carry out biosorption of lead and arsenic, this may be due to the fact that it is a gram positive bacteria with teichoic acid as source of carboxyl groups which are main agents in heavy metal uptake.

Bacillus comprises more than 300 species for those that have been vividly published (Harjodh *et al.*, 2018). *Bacillus lacus* AK 74 are motile, spore-forming aerobic bacteria or facultatively anaerobic bacteria. They can be found in water or soil and are alkali-tolerant.

Table 1: Biosorption of Heavy Metals by *Bacillus lacus* AK 74

Time(Day)	Pb			As		
	1.00 ppm	3.00 ppm	5.00 ppm	1.00 ppm	3.00 ppm	5.00 ppm
1						
7	0.310	1.125	1.508	0.328	2.000	3.015
14	0.185	0.730	1.307	0.200	1.532	2.680
21	0.050	1.106	2.218	0.065	1.110	2.625
28	0.010	0.316	1.082	0.040	0.725	2.590
% R	99.0	89.5	74.4	96.0	75.8	48.2

Key: ppm = part per million, % R = Percentage removal of heavy metal, Pb = Lead, As = Arsenic

Biosorption of Heavy Metals by *Herbaspirillum aquaticum* IEH 4430

Table 2 shows the biosorption potential of *Herbaspirillum aquaticum* IEH 4430 on heavy metals; Pb and As. Percentage removal of the metal follows this order: As > Pb and these were 75.5 % and 48.4 % at 1.0 ppm respectively. Highest percentage removal was observed at 1.0 ppm concentration compared to 5.0 ppm

concentration in the heavy metals analyzed. The decrease in percentage removal of the heavy metals as concentration increased might be due to decrease in binding site. This agrees with the findings of Puranik and Paknikar (2009), who reported that in a biosorption setup, increase in metal concentration beyond optimum level results in a retardation of sorption process due to increasing saturation of binding site, thereby leaving no space for more molecules of the metal to bind. *Herbaspirillum aquaticum* IEH 4430 has greater affinity for arsenic, hence, removal rate for arsenic was highest (75.5 %), however it was still found to be above maximum permissible limit of 0.1 mg/l (FEPA, 2003), on the 28th day.

Table 2: Biosorption of Heavy Metals by *Herbaspirillum aquaticum* IEH 4430

Time(Day)	Pb			As		
1	1.00 ppm	3.00 ppm	5.00 ppm	1.00 ppm	3.00 ppm	5.00 ppm
7	0.815	2.685	4.525	0.650	2.008	3.000
14	0.698	2.400	4.300	0.410	1.615	2.452
21	0.584	2.252	4.146	0.295	1.305	2.260
28	0.516	2.105	4.125	0.245	1.180	2.180
% R	48.4	29.8	17.5	75.5	60.7	56.4

Key: ppm = part per million, % R = Percentage removal of heavy metal, Pb = Lead, As = Arsenic

Conclusion and Recommendation

Biosorption potentials of bacterial isolates revealed that *Bacillus lacus* AK 74 had high potential to biosorb Pb (99 %) and As (96 %), while *Herbaspirillum aquaticum* IEH 4430 had potential to biosorb As (75.5 %) at 1.0 ppm. Gram positive bacteria (*Bacillus lacus* AK 74) had more efficient biosorption potential or percentage removal rate than gram negative bacteria (*Herbaspirillum aquaticum* IEH 4430). Bacterial species *Bacillus lacus* AK 74 can be used in remediation/clean up process of the respective heavy metals (Pb and As) polluted environment.

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ACUTE TOXICITY OF IMIDACLOPRID (20 % SL) ON THE JUVENILES OF *OREOCHROMIS NILOTICUS* (LINNEAUS, 1758)

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ABSTRACT

This Study was carried out under Laboratory conditions to ascertain the toxicity effects of imidacloprid (20% SL) on juveniles fresh water fish *Oreochromis niloticus* (Linnaeus, 1758). The Objectives of the Study are to determine the acute toxicity and behavioral pattern of *O. niloticus* to imidacloprid (20% SL). For the 96hr-acute toxicity test, the concentrations of the working solutions used for imidacloprid (20% SL) were 0.00ml/L, 0.001ml/L, 0.0015ml/L, 0.002ml/L, 0.025m/L and 0.003ml/L for T1, T2, T3, T4, T5, and T6 respectively. The LC50 of imidacloprid for *O. niloticus* was 0.002ml and the behavioural responses in the fish included erratic movement, vertical standing and uncoordinated swimming which were observed to be more pronounced as the concentration increased. The results of this study highlight the stress of freshwater fish exposed to controllable and uncontrollable discharge of insecticides in the aquatic environment.

Keywords: Imidacloprid; Acute toxicity, *Oreochromis niloticus*, insecticides

Introduction

Agrochemicals have been widely used in most agricultural sectors for enhancing crop yield where agriculture is anticipated to be the backbone of the economy (Doruchowski *et al.* 2017). Consequently, extensive application of pesticides poses potential risks to the biodiversity of freshwater aquatic environments because of their bioaccumulation and intrinsic toxicity (Cui *et al.* 2015). Imidacloprid is a systemic insecticide belonging to a class of chemicals called the neonicotinoids which act on the central nervous system of insects and is widely used for pest control in agriculture (Gervais *et al.*, 2010). This study will therefore, aimed at determining if imidacloprid is toxic to juveniles of *Oreochromis niloticus* or not.

Materials and Methods

Collection and Acclimatization of Experimental Fish

Two hundred and twenty (200) juveniles of *Oreochromis niloticus* with a mean weight of 10.86±0.26g were conveyed to the experimental site, and stocked 50 juveniles per 40litre transparent tank into four (4) holding tanks (40litre capacity) for two weeks (14) days (Fawole *et al.*, 2007) and fed 3% body weight with commercial feed them twice a day morning and evening. And the water were changed when polluted.

Acute toxicity studies

Acute 96 h static bioassays were conducted in the laboratory as described by (Ezike and Ugwu, 2015) to determine the toxicity of Imidacloprid to *Oreochromis niloticus*. A total of One Hundred and Eighty (180) fish were used. Eighteen (18) transparent plastic tanks of 40l capacity containing 30l of dechlorinated tap water were used. Six graded concentrations of Imidacloprid were used: 0.0ml/L (control), 0.001ml/L, 0.015ml/L, 0.002ml/L, 0.025ml/L, and 0.003ml/L. Control did not contain the toxicant. Ten (10) juveniles were stocked per replicate and estimated for mortality rate after 12, 24, 48, 72 and 96 hours periods. Dead fish were removed immediately to prevent water pollution. Feeding was stopped 24 hours before commencement and during the experiment. Water in the tank was replenished daily with dechlorinated municipal tap water and fresh toxicant. The 96hr lethal median concentration (LC50) was determined as a probit analysis using the probit mortality versus the logarithm concentration.

Water Quality Parameters

Physico-chemical parameters of the diluting water such as temperature, pH, and dissolved oxygen, , were measured during the acute test as described by APHA (1985).

Data Analysis

The experimental results were analyzed using one way analysis of variance (ANOVA) at $\alpha = 0.05$ level of significance. The differences among the treatments means were determined by Duncan multiple range test (1955).

Results

Water Quality Parameters

The water quality parameters monitored during the tests is presented on Table 1. The result showed that the temperature increased wit increase in concentration. The control (0.00ml/L) showed 22°C while at the concentration of 0.003ml/L, the temperature was 26°C. The dissolved oxygen had a range of 3.0-6.2 ppm; pH ranges from 5.22 to 5.89, There was significant difference ($p < 0.5$) in the Dissolved Oxygen values and pH.

Mortality of *Oreochromis niloticus* Exposed to Imidacloprid

Mortality occurred in all the culturing containers except in the control (0.00ml/L) (T1). The first mortalities of *Oreochromis niloticus* were observed in 12 hrs for container containing 0.003ml/L of Imidacloprid. By 48 hrs mortalities were observed in all concentrations except 0.00 and 0.001ml/L. The highest percentage value of 70 was observed at the highest concentration of 0.003ml/L followed by 60% at 0.002ml/L and 0.025ml/L. Figure 1 showed the LC₅₀ of *O. niloticus* to Imidacloprid to be 0.30 which is at 2mL(0.002ml/L) concentration of Imidacloprid.

Behavioural Responses of *Oreochromis niloticus* to Imidacloprid for 96 hours

Table 2 presents the behavioural responses of *O. niloticus* exposed to imidacloprid. Number code '1-8' represents different behavioural reactions in order of their appearances. Agitated movement and loss of equilibrium occur across all the concentrations from 0.001ml/L to 0.003ml/L. The behavioural responses of air gulping occurred under doses of 0.002ml/L to 0.003ml/L, while sign of weakness and skin colouration occurred from the dose of 0.002ml/L to 0.006ml/L and more pronounce between 0.002ml/L to 0.006ml/L; these were presented on table 2

Table 1: Water Quality Parameters

Conc.(ml/L)	Temperature .°C	Dissolved oxygen (ppm)	pH
T1 (0mL)	22± 0.05 ^a	6.2±0.00 ^c	5.22±0.11 ^a
T2 (0.001mL)	23±0.10 ^a	4.2±0.11 ^b	5.6±0.04 ^b
T3 (0.015mL)	24±0.55 ^b	3.2±0.20 ^a	5.72±0.33 ^b
T4 (0.002mL)	23±0.01 ^b	3.1±0.50 ^a	5.71±0.40 ^b
T5 (0.025mL)	25±0.22 ^c	3.0±0.00 ^a	5.89±0.25 ^c
T6 (0.003mL)	26±0.03 ^c	3.0±0.00 ^a	5.55±0.01 ^b

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Table 2: Behavioral Responses of *Oreochromis niloticus* Exposed to Imidacloprid

at 96 hours.

Behavioral Responses	Doses of Imidacloprid in ml/L					
	T1 (0mL)	T2 (0.001mL)	T3(0.015mL)	T4(0.002 mL)	T5(0.025mL)	T6(0.003mL)
Agitated movement		2	1	1	0	0
Loss of equilibrium			2	2	2	2
Air gulping		2	3	3	4	5
Sign of weakness		1	2	3	4	5
Skin colouration		3	5	5	6	8

1-5 = Behavioral responses in different concentrations of Imidacloprid

KEYS

Agitated movement = 4

Loss of equilibrium = 6

Air gulping =17

Sign of weakness = 15

Skin colouration= 27

Table 3: Probit Value of *Oreochromis niloticus* Exposed to Imidacloprid at 96 hours

Conc.(mL)	Log conc.	Total fish exposed	No.of mortality	% Mortality	Probit value
T1(0mL) (Control)	0.00	10	0	0	0.00
T2 (0.001mL)	0.00	10	2	20	4.16
T3 (0.015mL)	0.18	10	3	30	4.48
T4 (0.002mL)	0.30	10	6	60	5.25
T5 (0.025mL)	0.40	10	6	60	5.25
T6 (3.0mL)	0.48	10	7	70	5.52

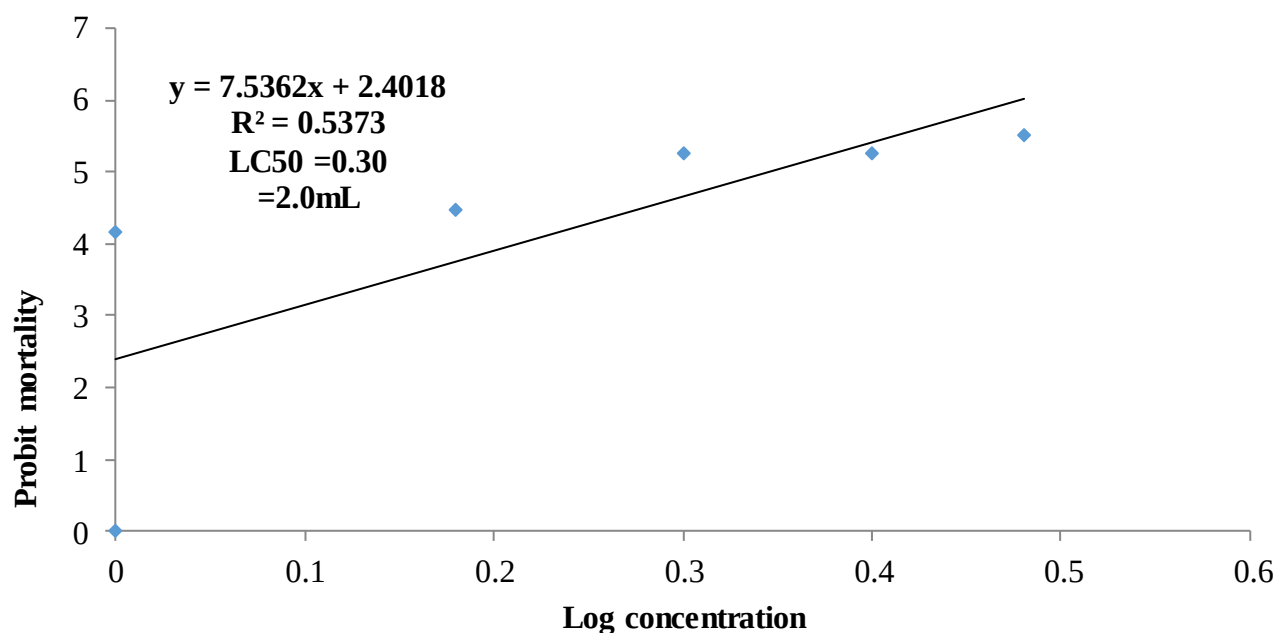


Figure 1: Mortality of *O. niloticus* exposed to Different Concentration of Imidacloprid

Discussion

The lethal toxicity test showed that fish in the control tank survived whereas mortalities were recorded in all treatment concentrations. Mortality increased with increasing concentration of the toxicant in water. Many authors made similar observation on different fish species exposed to varying levels of toxicants (Umar *et al.*, 2010). Omoniyi *et al.* (2002) reported accumulation of mucus on gills which reduced respiratory activity due to inability of the gill surface to actively carry out gaseous exchange and to mortalities. The results of the water quality of the test media was within the optimal range recorded by Omoregie *et al.* (2009). The fish exhibited stressful behaviour which increased with toxicant concentration. Similar behaviour was reported by Fafioye *et al.* (2001) on *Clarias gariepinus* and Rahman *et al.* (2002) on *Clarias punctatus*. They observed restlessness and uncoordinated swimming might be due to its stimulant effect Umar *et al.* (2010) specifically identified to inhibit cholinesterase enzymes to acetylcholine receptors in the nervous system of exposed fish which resulted to excitation and restlessness. Aktar *et al.* (2019) reported that the used of imidacloprid has a serious consequences for human, aquatic life and environment.

CONCLUSION

Acute toxicity level at 0.002ml/L of Imidacloprid could cause 50% mortality. The levels below 0.002ml/L may be safe for juvenile *O. niloticus* but cautionary measures must be employed in its application as agro-chemical.

RECOMMENDATIONS

Government through the Ministry of Agriculture should conduct periodic awareness campaigns on impacts of Imidacloprid as pesticides (insecticides) on environment and their threshold concentration to ensure appropriate use.

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ACUTE TOXICITY OF ATRAZINE (HERBICIDE) TO JUVENILES OF THE AFRICAN CATFISH, *CLARIAS GARIEPINUS* (BÜRCHELL, 1822)

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ABSTRACT

In the present study, juveniles of *Clarias gariepinus* were exposed to the herbicide atrazine in order to determine the herbicide's toxicity to the species at both acute and sub-lethal exposures. Fish were exposed to acute concentrations of 20, 22.5, 25, 27.5 and 30mg/l of atrazine. Experiments had a control that served as a reference point. Effects of the herbicide were measured using behavioral as well as growth indices (as suggested by previous authors). Results of the acute toxicity test showed that atrazine was toxic to the species in a dose-dependent manner. The LC₅₀ value of atrazine established for the species was 23.59mg/l. Most importantly, atrazine induced hyperactivity at acute levels of exposure. The study revealed that atrazine was moderately toxic to *C. gariepinus* juveniles and affected the behavior as well as growth of the fish. Hence, use of the herbicide should be with caution.

Keywords: **Atrazine, Acute, Toxicity, Lethal concentration, *Clarias gariepinus***

Introduction

The ever-increasing world population and the attendant increase in food demand necessitated that new ways of increasing agricultural output be sought. In an attempt to increase agricultural output, man relies heavily on the use of chemicals to protect crops from pests, right from the time of dressing of seeds before planting, through fighting weeds and other pests on the farm, to the preservation of already harvested products. On one side, benefits derived from the use of pesticides in agriculture are immense, but on the other side, environmental pollution and/or degradation is one major problem that is linked to their application (Olusegun, 2001).

The aquatic environment is particularly one vulnerable area as it is the ultimate recipient of pollutants due to basin drainage. The aquatic ecosystems have been known to receive a wide spectrum of pollutants, which may be introduced to them directly or indirectly. The indiscriminate use of chemicals has resulted in large scale reduction in aquatic productivity. Pesticides have different diverse impacts on aquatic animals especially fishes which are of economic importance and high value from the point of biological conservation (Mekki et al., 2013). Fish is highly nutritious, easily digestible and a much sought after food. Nutritional value of fish depends on their biochemical composition, which is affected by water pollution (Prado et al., 2009). The African catfish, *Clarias gariepinus* is one of the richest source of animal protein to man.

Atrazine (2-Chloro-4-ethylamino-6-Isopropylamino-s-triazine) is one of the most currently and widely used herbicides in this part of the world and several studies have detected its presence in water bodies at levels above the limits determined by local and international authorities. Due to its potential to bioaccumulate in organisms and its proposed negative effects, the application of atrazine has been banned in many countries. Hence, the tolerance limit of this herbicide on this promising species needs to be investigated.

Mortality or bioassay experiments in general present the most preferred way to evaluate the ecological influence of toxic compounds as their effects on fish and ecological risks cannot be determined by chemical analysis (Baser *et al.*, 2003). Acute toxicity tests provide basis for understanding the limiting effects of various chemicals on organisms.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Fish Hatchery Laboratory of the Department of Fisheries and Aquaculture, Bayero University, Kano, Nigeria.

Experimental fish

One hundred and eighty (180) *C. gariepinus* (mean weight, 24.56 ± 0.7 g and mean standard length of 15.42 ± 0.3 cm) juveniles were used for the study, fish were purchased from a reputable fish farm from Kano, Kano State.

Source and Processing of Atrazine

The atrazine (AtraForce® 50% SC) was procured from Samlet Nigeria Limited, Sabon Gari Market Kano, a supplier of Laboratory Chemicals and Equipment.

Preparation of the test Solution

AtraForce® 50% SC was obtained at a concentration of 500g/L in a one liter container. From the 500g/L, a stock solution was prepared by adding 1ml of the herbicide to 999ml of water. (The stock solution was then used to prepare different nominal concentrations of the toxicant by diluting measured volumes of the toxicant with dechlorinated tap water. The control solutions had only dechlorinated tap water without the toxicant.

Physicochemical Parameters of Test Solution

Water quality parameters such as temperature, pH, conductivity, total dissolved solids and dissolved oxygen concentration were monitored in the tanks using digital multi-parameter checker (HI 98126).

Range finding

Based on available literature on acute toxicity test on tropical freshwater fish species, range-finding tests were conducted to determine the concentrations of atrazine that were used in the definitive tests. This was done by placing six concentrations of the herbicide in separate plastic bowl containing 20 litres of water. Mortality of fish was determined at 12, 24, 48, 72 and 96 hours. The concentrations of the herbicide were fine-tuned using lower ranges until about 85 to 95% mortality was recorded in the highest concentration and 25 to 30% in the lowest concentration. The five concentrations used in the acute test were then geometrically ranged between these highest and lowest concentrations and made into triplicates.

Definitive Test

Results from range finding tests provided guide for the concentration level to be used in definitive test. The definitive test was carried out by filling eighteen (18) plastic tanks with 20 litres of water each. The test was carried out using concentration of atrazine earlier determined from range finding test. The concentrations used were 20mg, 22.5mg, 25mg, 27.5mg and 30mg of atrazine per litres of water (mg/l). The response of the fish to slight stimuli was used as an index of toxicity while non-response of the fish to atrazine powder estimated to be lethal to 50% of the test organism after 96 hour of exposure.

Experimental Design

Completely randomized design was used for the experiment. A total of eighteen (18) plastics tanks of (60cmx40cmx40cm) capacity were used. The plastic tanks were washed thoroughly and then filled with 20 litres of water. All plastic tanks were labelled. Fish were weighed and distributed at the rate of 10 fish per tank. A total of one hundred and eighty (180) of *C. gariepinus* juveniles were randomly stocked into the tanks at a stocking rate of 10 fish per tank in triplicates.

Statistical Analysis

The mean lethal concentration LC_{50} at selected periods of exposure and an associated 95% confidence interval for each triplicate toxicity test were subjected to Mini tab 16. ANOVA was used for mean comparison. LSD was used for comparison among the treatments and the control at 0.05% level.

RESULTS AND DISCUSSION

The mortality rates of *Clarias gariepinus* exposed to various acute concentration of TSH powder are shown on Table 1.

Table 1: Mortality table of *Clarias gariepinus* juveniles exposed to acute concentration of Atrazine

Treatment(mg/L)	No of Fish	Total Mortality	%Mortality	Log. Conc.	Probit
0.0	30	0	0.00	0.00	0.00
20.0	30	8	26.67	1.30	4.39
22.5	30	13	43.33	1.35	4.82
25.0	30	18	60.00	1.40	5.25
27.5	30	22	73.33	1.44	5.61
30.0	30	26	86.67	1.48	6.13

Mortality was directly proportional to the concentration of the toxicant and the length of exposure of the fish to the toxicant. The mortality was observed to be concentration and time dependent in this study. This shows that increase in concentration of atrazine resulted in higher mortalities. In this study the highest mortality rate (86.67%) was recorded in T5 (30 mg/l) while the least mortality rate (26.67%) as recorded in T1 (20 mg/), Ateeq *et al.*, (2005), Olurin *et al.*, (2006) and Isiyaku *et al.*, (2019) report similar trend in exposure of *Clarias gariepinus* to 2, 4-D butachlor, glyphosphate herbicides and tamarind seed husk powder respectively. It has also been stated that substances could be poisonous when exposed to organisms beyond certain concentrations and time limit according to Ogundele *et al.*, (2004). It was observed that the mortality recorded in this investigation increased with increase in the concentration of TSH powder. The first death was noticed 56 minutes after the introduction of toxicant in the bowl with the highest concentration of atrazine (20mg/l). This is in conformity with Isiyaku *et al.*, (2019) who reported the first death in 30 minutes after introduction of toxicant to *Clarias gariepinus* in acute concentration of mercuric chloride. Olaifa *et al* (2004) reported the first death three hours after the introduction of toxicant in the exposure of *Clarias gariepinus* to lethal concentration of copper. Datta and Kaviraj (2002), Fafioye *et al.*, (2004) and Okomoda *et al.*, (2010) recorded the first death 36 hours after the exposure to acute toxicity treatment of *Clarias gariepinus* with synthetic Pyrethyroid Deltamethrin, Raphia vinifera extracts and formalin respectively. Guedenon *et al.*, (2012) recorded the first death after 30 hours while treating *Clarias gariepinus* with 120mg/l of cadmium sulphate. The duration of resistance of *Clarias gariepinus* in the present study appeared to be lowest compared to those in the aforementioned studies. The 96-hour median lethal concentration (LC₅₀) of atrazine for *Clarias gariepinus* using the probit method was found to be 23.59mg/l (Figure 1).

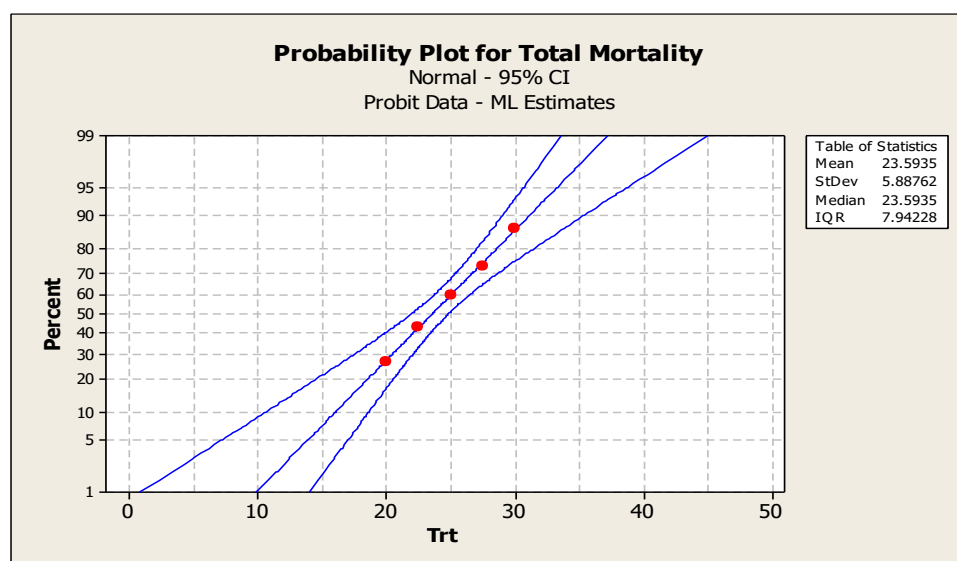


Figure 1: Linear relationship between mean probit mortality and log concentration of *Clarias gariepinus* juveniles exposed to acute concentrations of Atrazine for 96 hours.

Water is the medium in which fish carry out their life functions, such as feeding, swimming, breeding, digestion, and excretion (Bronmark and Hansson, 2005). Water quality is the major factor responsible for

individual variation in fish haematology. The water quality parameters recorded were within acceptable ranges for toxicity test (APHA, 1998). They may not have acted synergistically with the toxicant to affect the behavior as well as mortalities recorded in this study. The physico-chemical parameters of the test water measured during acute toxicity bioassay were within suitable ranges for the survival and normal growth of *C. gariepinus*. Hence changes in fish behavior and subsequently death could not have arisen from poor water quality of the test water (Badiru, 2005). Similar observations were reported by Ramesh *et al.* (2009) who works on common carp expose to atrazine and Mekkawy *et al.* (2013) who expose atrazine to *Clarias gariepinus*.

It was observed that pH decreased as well as dissolved oxygen. This might be due to the effects of atrazine powder on the water quality. This is similar to Ayuba *et al.*, (2012) who worked on *Datura innoxia* root extracts. Even though total dissolved solids and electrical conductivity values differed significantly ($P < 0.05$) as compared to the control values, they were still within acceptable limits. Temperature was not statistically different between groups possibly because atrazine powder may not have reacted as in exothermic or endothermic. However, oxygen concentration reduced with increased concentration of atrazine powder. Generally toxicity increased with reduced oxygen concentration. This is similar with reports by Adigun (2003) and (Ayuba *et al.*, 2012) who worked on different toxicants.

Table 2: Water quality parameters of the experimental units during the acute toxicity test of *Clarias gariepinus* juveniles exposed to Atrazine.

S/N	Treatment	pH	TEMP ($^{\circ}$ C)	TDS (mg/l)	EC (μ S)	DO
1	0.0	7.43 $\pm$ 0.03	25.53 $\pm$ 0.07	67.87 $\pm$ 0.09 ^a	135.73 $\pm$ 0.18 ^a	4.73 $\pm$ 0.03 ^e
2	20.0	7.47 $\pm$ 0.03	25.53 $\pm$ 0.03	69.50 $\pm$ 0.13 ^b	139.00 $\pm$ 0.26 ^b	4.57 $\pm$ 0.03 ^d
3	22.5	7.37 $\pm$ 0.07	25.53 $\pm$ 0.09	70.68 $\pm$ 0.03 ^c	141.37 $\pm$ 0.07 ^c	4.52 $\pm$ 0.02 ^{cd}
4	25.0	7.43 $\pm$ 0.07	25.46 $\pm$ 0.09	73.52 $\pm$ 0.06 ^d	147.03 $\pm$ 0.12 ^d	4.46 $\pm$ 0.01 ^{bc}
5	27.5	7.37 $\pm$ 0.03	25.53 $\pm$ 0.09	77.07 $\pm$ 0.06 ^e	154.13 $\pm$ 0.12 ^e	4.41 $\pm$ 0.01 ^b
6	30.0	7.33 $\pm$ 0.03	25.57 $\pm$ 0.03	79.58 $\pm$ 0.09 ^f	159.17 $\pm$ 0.19 ^f	4.34 $\pm$ 0.01 ^a

Mean in the same column with different superscript differ significantly ($P < 0.05$).

CONCLUSION AND RECOMMENDATION

The physico-chemical parameters of water such as Temperature, dissolved oxygen, pH, electrical conductivity and total dissolved solids were within normal range. The median lethal concentration of atrazine powder was 23.59mg/l showing that atrazine was toxic to fish. Atrazine significantly induced anemia, leukocytosis and lymphocytosis. The indiscriminate use of pesticides as well as their use near water bodies should be discouraged. Instead, more environmental friendly approaches to pest control (such as biological control) should be explored. There is the need for the relevant authorities to intensify efforts at making environmental policies that will keep the use of pesticides in check as well as a periodic review of such policies based on the emergence of new facts.

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EFFECT OF SEX ON HEAVY METALS CONCENTRATION IN *Distichodus rostratus* (GUNTHER, 1864) FROM RIVER RIMA SOKOTO, NIGERIA

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ABSTRACT

This study assessed the effect of sex on concentration or accumulation levels of some heavy metals, namely: Cu, Cd, Pb and Zn in a 40 samples of freshwater fish muscles (*Distichodus rostratus*) from Rima River during the period of March – June 2016. The data obtained were analyzed using SPSS version 20.0 where T-test was adopted in checking sex effects. Conclusively the results shows that accumulation levels in fish do not exceeds the metals permissible level (Cadmium: 2.0, Copper: 3.0, Lead: 2.0 and Zinc: 75; all in mg/L), and this indicates bioaccumulation in fish muscles. The bioavailability differences were not significant in sexes, but levels of concentration in fish at each month of the samples collection were varied but within the recommended range for fishes.

KEYWORDS:

INTRODUCTION

Extensively a natural aquatic environment may be contaminated with heavy metals released from domestic, industrial and other man-made activities (Balogun, 2015). A small number of such elements are required only by the body in minute quantities, hence can be toxic in larger amounts: examples are lead (Pb), zinc (Zn), copper (Cu), cadmium (Cd), manganese (Mn) and so on (Joy *et al.*, 2013). In aquatic ecosystem trace element may be of natural origin from rocks and soil or from human activities e.g., industry, urban and agricultural discharge, mine runoff, solid waste disposal and atmospheric deposition. Unlike other pollutants

of organic origin, metals are not degraded or eliminated from the ecosystem (Rajkowska and Protasowicki, 2013) and accumulated in sediments and organisms (Zoumis *et al.*, 2001; Ikem *et al.*, 2003; Mendil and Dogan Ulouzlii, 2007).

A study revealed that *Distichodus rostratus*, is commonly known as the grass eater, belongs to the Family Distichodontidae (Shinkafi *et al.*, 2013). According to Nelson (2006), the species are found in freshwater. The species plays an important role in the ecosystem and fisheries of West Africa and other inland waters, as it constitutes an important trophic web of ecosystem and has been introduced into many artificial lakes and reservoirs such as Kiru, Kariba and Tiga Dams in parts of Africa (Coulter, 1970). The species are among the major exploitable fish species and are widely distributed in Nigeria, Nilo-Sudan, Niger, Volta, Chad, and Nile basins (Teugels *et al.*, 1992). Prior to their introduction into artificial lakes, they had colonized artificial lakes from natural riverine habitats (Abowei, 2010). *Distichodus rostratus* lives along the grassy banks of rivers and swamps and they are extremely fecund with their ovaries containing a great number of eggs and can attain a length of more than 60cm and above 6kg in northern Nigerian waters (Reed *et al.*, 1967; Motwani and Kanwai, 1970). In Nigeria, *Distichodus spp* are cultured in fish farms and numerous lentic water bodies due to their ability to feed on grasses and weeds (Nwani and Ude, 2005)

MATERIALS AND METHODS

Description of study area

Sokoto is located at the following coordinates: 13°04'N 5°014'E/13.67°N 5.233°E and the city is in the extreme north-west of Nigeria, near the confluence of the Sokoto River and Rima River. The climate of Sokoto is tropical continental, where it rains much between June and September, with long dry season from October and May as Ita *et al.*, (1982) revealed. The annual average temperature is 28.3°C (82.9°F), while maximum day time temperatures are generally 40°C (104°F) most of the year. According to Usman (unpublished undergraduate project work, 2012), Rima River serves as a cesspool for urban drainage and agro-industrial effluents in Sokoto, Nigeria. These chemicals eventually find their ways into this water body and cause a threat to the living organisms in the water, particularly fish.

River Rima has several landing sites: Kwalkwalawa is the biggest as it serves as fish mongers' main centre for selling catches and even cultured species. The Kwalkwalawa landing site was the source of the experimental sample fishes.

Sample and sampling technique

Samples of *Distichodus rostratus* were collected in batches from Kwalkwalawa fish landing site, that, is five (5) samples each of adult male and female *Distichodus rostratus* were purchased randomly and monthly for a period of 4 months (March-June, 2016) giving a total sum of forty (40) fish samples as the sample size. Fresh fish (catch) and fully matured was always preferred. Freezing and solar drying means of preservation to avoid deterioration were adopted. Identification was based on the descriptions of Reed *et al.* (1967); Olaosebikan and Raji (1998).

Laboratory analysis

Samples collected were digested by combining two digestion techniques namely: Nitric acid digestion technique (APHA, 1997) and hydrochloric acid digestion technique (Allen *et al.*, 1984). Meaning that 1g of each sample were taken, 10ml of Nitric acid (HNO₃) and 2ml of per-chloric acid (HClO₄) were added and heated for ten minutes, until a brown colour was observed with white fumes. After digestion, the solution was filtered through a filter paper and diluted with distilled water up to 50ml each in separate bottles or container. From the solution obtained, the concentration levels were detected at different wavelengths (Cd: 228.8; Cu: 324.8; Pb: 283.3 and Zn: 213.9 all in nanometres) on atomic absorbance spectrophotometer machine.

Statistical analysis

SPSS 20.0 for windows was used to analyze the data obtained. T-test for comparing 2 independent sample means for sex variability

RESULTS AND DISCUSSION

Table 1 shows that the concentration of cadmium, copper, zinc, and Lead were not statistically significant ($P>0.05$) when compared between male and female of the species caught from the water body. Moreover, the mean concentration of cadmium, copper and lead were found to be higher in male samples than in females, whereas zinc concentration was highest in female samples.

Table 1: Sex variability on heavy metals concentration in *Distichodus rostratus* of River Rima, Sokoto, Nigeria

Parameters	Sex	
	Male	Female
Cadmium	0.09±0.50	0.07±0.50
Copper	0.76±0.48	0.69±0.50
Lead	1.20±1.27	1.14±1.52
Zinc	0.28±0.20	0.32±0.33

The result from the research finding shows that there is no significant difference between the sexes accumulation or concentration level, which is going against the work of Andres *et al.*, (2000); Canli and Atli, (2003); Farkas *et al.*, (2003) that says sex is among the factors which influence heavy metals accumulation in fish tissue.

From the data analyzed, it points out that the concentrations of heavy metals in *D. rostratus* fish muscles were all within the maximum permissible limits by WHO (1985) and FEPA (2003), and this indicated bioaccumulation which is in line with Yilmaz *et al.*, (2007); Obasohan and Eguavoen (2008) and Zhao *et al.*, (2012). On the other hand, the result is contrary to what was reported by Mastan (2014): that the heavy metals analyzed were above the permissible limits of FAO/WHO (1984).

The low concentrations were as a result of proves by previous research which says muscles of fish is always expected to accumulate least heavy metals concentration (Mastan, 2014). Again Forstner and Wittman (1981); Kottelat and Freyhot, (2007); Doadrio *et al.*, (2011) stated that herbivorous fish show low level of heavy metals absorption and *D. rostratus* is a grass eater (Shinkafi *et al.*, 2013). Other factors contributed to this absorption levels are seasonal variation (Ahmed *et al.*, 2013); contaminated run-off, mining and industrial activities, time of exposure, way of metal up take, environmental conditions (water temperature, pH, hardness, salinity) and intrinsic factors (fish age, feeding habits, body size) (Tekin-Ozan and Aktan, 2012; Jezierska and Witeska, 2006); Study by Nsikak *et al.*, (2014) showed that urea and superphosphate fertilizers sold commercially in Nigeria contains considerable amount of heavy metals, and the River Rima is facing similar attribute as reported by Usman, (2012).

CONCLUSION

The study concluded that the concentrations of zinc, Cadmium, Lead, and copper in all samples collected of *Distichodus rostratus* analyzed were within the maximum permissible limits with an order of bioaccumulation as Cadmium<Copper<Lead< Zinc (0.1175±0.0213, 0.3198±0.3600, 0.7213±0.3295 and 1.1856±0.7610 as their grand total of each respectively); fish sex and heavy metal concentrations showed consistent negative relationships.

Again, why the heavy metals concentrations were found not in much are as a result of the trophic level of the fish as it is in the lower part and is it known that fish that are in the upper trophic have higher tendency to accumulates heavy metals. Also, muscles tissues possess low concentration of heavy metals compared to other tissues of the fish body (S.A Mastan 2014 and Akan *et al.*, 2012). Season also plays a vital role in

possibilities of accumulating heavy metals as in wet season fish has higher tendency to accumulate heavy metals than in dry season.

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ABSTRACT

Heavy metal refers to any metallic element that has a relatively high density greater than 5 g/cm³ and above and is toxic or poisonous even at low concentration. Heavy metals are among the preeminent pollutants of the environment due to their persistent, non-degradable nature in the environment, toxicity and accumulative character in benthos, fishes, sediments, water and soil. Heavy metals enter the environment and aquatic ecosystem through the natural and anthropogenic sources. The natural sources are weathering of rocks and soil, soil erosion and volcanic eruption, while the anthropogenic sources are industrial and domestic wastes, sewage, mining and smelting, textiles, tanneries and agricultural activities. Some heavy metals such as, Cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), magnesium (Mg), mercury (Hg), lead (Pb), nickel (Ni), silver (Ag) and arsenic (As) are non-essential and are associated with environmental science. Cd, Cr, Pb, Hg and As are toxic to both humans and fishes and their accumulation in the body tissues of fishes and humans could be deadly. While, Cu, Zn, cobalt (Co), Mg, Mo and Se are essential heavy metals, they are important for physiological and biochemical functions in biological system. High amount of heavy metals has inhibitory effects on the development of fishes, and their metallic compounds can disturb the oxygen level and many histological changes such as gill necrosis or fatty degeneration of the liver occur in the fish. The review aims to discuss the Bioaccumulation and Toxic effects of As, Cd, Cr, Pb and Hg on Fish, so that critical actions can be taken to curtail the consequences of these heavy metals in our environment.

KEYWORDS: Bioaccumulation, Toxicity, Heavy Metals and Fish

Introduction

Heavy metal refers to any metallic element that has a relatively high density greater than 5 g/cm³ and above and is toxic or poisonous even at low concentration (Lenntech, 2004). Environmental pollution by pollutants such as heavy metals have become a problem of great concern globally to humans and aquatic ecosystem, due to their bioaccumulation and bio magnification, and their toxicity. Humans and fish exposures have escalated suddenly due to the high increase in the uses of heavy metals in several industrial, agricultural, domestic and technological applications. Also the expansions in the urbanization and industrialization nowadays have contributed large amounts of heavy metals, which have somewhat enforced unfavorable shock on the nature of water features of the rivers, ponds and lakes globally (Bakshia and Panigrahib, 2018).

Heavy metals enter the aquatic environments through effluents from industries such as tanneries, textiles, mining, dyeing, printing, pharmaceuticals, rubbers and stainless steel manufacturing industries, domestic wastes and agricultural practices (Bakshia and Panigrahib, 2018). Others are street runoffs, domestic and municipal effluents, metal corrosion, atmospheric depositions, soil erosions of metal ions and leaching of heavy metals, sediment re-suspension and metal evaporation from water resources to soil and ground water (Paul *et al.*, 2012), and lastly rocks and soil weathering, and volcanic eruptions have significantly increased heavy metals pollution.

The following heavy metals are considered as essential heavy metals, they are Cu, Zn, cobalt (Co), Cr, Mg, Mn, Mo, Ni and selenium (Se). They are essential nutrients that are needed for diverse physiological and biochemical functions, (that is, they are essential to keep the body anabolism and catabolism) in animals such as humans and fishes. However, at higher concentrations the essential heavy metals have damaging effects on tissues that leads to diverse adverse effects on humans and fishes. These other heavy metals, As, Cd, Pb, and Hg are called non-essential heavy metals, they have no known biological functions in plants and animals such as humans and fishes. Heavy metals are persistent and non-biodegradable, toxic, and it accumulate in food chains and pollute it. Incessant exposure to heavy metals in the environment is a genuine hazard to living organisms.

The essential heavy metals have exercise some major roles in physiological and biochemical action in animals and plants. They are valuable contents of various vital enzymes that play critical roles in several redox reactions. For instance, Cu aid as a vital co-factor for assorted oxidative stress-related enzyme including catalase, peroxidase, ferroxidases, superoxide dismutase and monooxygenase. Therefore, it is some vital nutrients that is involved in the formation of hemoglobin, carbohydrate metabolism, and cross-linking of collagen, elastin, and hair keratin. Exposures to higher concentrations of Cu can lead to cellular damage. The aims of this review is to discuss the Bioaccumulation and Toxicity of Heavy Metals in fish.

Bioaccumulation and Toxicity of Heavy Metals in Fish

Bioaccumulation means an increase the level of a chemical/toxicant (such as toxic heavy metals) in various tissues of living organism over time, when compared to the chemical/toxicant level in the environment. It takes place within an organism when the rate of intake of a substance is greater than the rate of excretion or metabolism of substances. Environmental pollution by heavy metals is one of the major challenges in the modern human society and it is a serious threat to the environment, and is of great concern to the environmentalist. Heavy metals occur from both natural and anthropogenic processes and end up in different environmental compartments (soil, water and air). Natural sources in the environment include weathering of rocks, soil erosions and volcanic eruptions, while the anthropogenic sources are domestic and municipal wastes, mining, industrial effluents, urban runoff, sewage discharge and agricultural activities like application of pesticides and phosphate fertilizers (Hazrat *et al.*, 2019).

In the aquatic ecosystem, heavy metals are being accumulated in water, sediments and biota such as fish. Also, in the aquatic ecosystem, fish occupy the top most position in the trophic level of food chain, therefore, fish species can accumulate and biomagnify pollutants such as heavy metals from water, sediments and benthic organisms. Since heavy metals are persistent in the environment, they accumulate in the tissues of living organisms and are transferred from one trophic level to another in the food chains. The extent of accumulation of heavy metals in biota depends on their rate of accumulation and their rate of elimination from the body.

Heavy metals may enter the body of an organism (fishes or humans) directly from the abiotic environment, that is, water, sediments, and soil or may enter the organism body from its food/prey. For example, heavy metals may enter the fish body directly from water or sediments through the fish gills/skin or from the fish food/prey through its alimentary canal. Bioaccumulation and bio magnification are being controlled by factors such as PH, temperature, hardness, exposure time, feeding habit and habitat (Hazrat *et al.*, 2019). The bioaccumulation of toxic heavy metals in the body tissues of fish can damage fish health and cause casualty to their usual physiological functions.

Heavy Metal Toxicity/ Poisoning, Toxicity refers to the property of a chemical to affect survival, growth, and reproduction of an organism. Nonessential heavy metals (Cd, Pb, As and Hg) are toxic and they have been reported by Hazrat *et al.*, (2019) to be carcinogenic, mutagenic, and/or teratogenic to different species depending on concentration and exposure time. They are toxic chemicals in the environment, to plants, animals (like fish), and humans even at very low concentrations. Toxic heavy metals can be transferred to humans through food chains and heavy metal poisoning can occur if fish or humans consume food that is polluted with heavy metals. The toxicity of heavy metals can severely influence the rate of survival and reproduction ability of fishes. Toxicity of heavy metals at times damages the nervous system of fish which influence their effect with the environment. Prolonged exposure of heavy metals on fish have displayed much influence not only on growth but on survival of fishes too.

Arsenic (As)

As is ever-present and it enters the aquatic environment through several anthropogenic sources such as mining, smelting operation, power plants, manufacturing company and agricultural field that uses herbicides, pesticides and fungicides. Food and water that are polluted with arsenic enter fish via their gill and skin. Arsenites is the form of As that is very quickly absorbed into the body tissues of fish and it is more toxic. The toxicity of As is dependent on pH, temperature, salinity and some organic matters. As bioaccumulate in the liver and kidney of freshwater fish, and it alters the gills and liver of freshwater fish, tilapia.

Cadmium (Cd)

Cd is a nonessential element and is one of the most toxic heavy metals for aquatic organisms, due to its high rate of bioaccumulation and low rate of excretion. Cd is broadly spread in the earth's crust; it is present in highest form in the sedimentary rock. Cadmium is frequently used in the production of alloys, pigments, and batteries. Cd^{2+} is the most toxic form of Cd. The highest concentration of Cd accumulation occurs in the liver, gills and kidney of fishes, and the accumulation results in DNA damage and causes severe toxicity to fishes.

Chromium (Cr)

Cr occurs naturally and it is present in the earth's crust and seawater, and it has Cr^{2+} , Cr^{3+} and Cr^{6+} oxidation states. Cr^{3+} and Cr^{6+} are the most stable forms. Cr^{3+} oxidation state is less toxic, while Cr^{6+} oxidation state is the most toxic because it has strong oxidative potential to move across the cell membrane. The toxicity of Cr in aquatic environment came from anthropogenic sources such as wood preserving, alloy preparation, textile manufacturing, metal processing, petroleum refining, domestic and sewage wastes, mining and agricultural activities. Cr toxicity on fishes is dependent on the age developmental stage of fishes and pH, temperature and the alkalinity of water. When fishes are exposed to Cr some physiological changes like erratic movement, change in bodily color and loss of appetite. High exposure of Cr to fishes indicated depletion of liver glycogen content in a freshwater teleost. It also depicted osmoregulatory and respiratory dysfunction at pH 7.8 and 6.5. High Cr accumulation takes place in the gills, liver and kidney and the lowest in the muscles of fishes (Pellibudak and Erdem, 2014).

Lead (Pb)

Pb is a bluish-grey element that occurs naturally, in abundance in the earth's crust. Anthropogenic sources such as mining, fossil fuel burning, manufacturing industries, lead-arsenate pesticides, battery manufacturing, lead-based paints and pigments has contributed high concentration of Pb in the environments. Pb enters the aquatic ecosystem from several sources such as storm street runoff, agricultural field, domestic wastes, sewage and industrial effluents which resulted in high concentrations of Pb in the aquatic environment, that caused toxicity of Pb in benthos and fishes. 10-100mg/L is the lethal concentrations of Pb in fish. Sublethal dose of Pb in fish causes physiological changes such as impotency and growth retardation of fish. Pb also caused distortion in gills and liver tissues in African catfish and in *Oreochromis niloticus* it indicated lowered haemoglobin (Afahan *et al.*, 2014).

Mercury (Hg)

Hg occurs in nature in three forms, elemental, inorganic and organic and each of them have different toxicity on humans and fishes, and Hg also exists in Hg^{+1} and Hg^{2+} ionic state. Hg is far-reaching environmental poison and pollutants that causes detrimental health effect on humans and fish, it is regarded as one of the most toxic heavy metals in the environment. Methylmercury (CH_3Hg) is the organic form of Hg and it is formed by methylation of inorganic forms of Hg by organisms present in soil and water, CH_3Hg is the most chemically toxic form of Hg. Hg is the third most dangerous substance in the environment after Pb and As by United State Environmental Protection Agency (USEPA) and the Agency for Toxic Substance and Disease Registry (ATSDR). Hg enters the environment through volcanic eruption and forest fire and anthropogenic sources such as batteries, paint, fungicides for wood processing, mining, dental amalgams and others. Hg enters into the fish body by diet via the gills, skin and alimentary canal, the intense fatal concentration of inorganic Hg is 0.3-1.0 mg/L for salmon. In fish, CH_3Hg is the most neurotoxic and can accumulate in the nervous system of fish.

CONCLUSION

Heavy metals such as Cu, Zn, Co, Cr, Mg, Mn, Mo, Ni and Se are treated as essential heavy metals. They are essential nutrients that are needed for diverse physiological and biochemical functions. However, at higher concentrations the essential heavy metals have damaging effects on tissues that leads to diverse

adverse effects on humans and fishes. Heavy metals like As, Cd, Pb, Hg and Ni are called non-essential heavy metals, they have no known biological functions in plants and animals such as humans and fishes. Heavy metals enter the aquatic ecosystem via natural and anthropogenic sources. Fish species can accumulate and biomagnify pollutants such as heavy metals from water, sediments and benthic organisms, the bioaccumulation of toxic heavy metals in the body tissues of fish can damage fish health and cause casualty to their usual physiological functions

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TOXICITY OF AMPICILLIN ON *CLARIAS GARIEPINUS* (BURCHELL, 1822)

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Abstract

The research aimed at determining the toxicity effects of Ampicillin on behavioural responses, water quality and mortality of *Clarias gariepinus* juveniles in static bioassay for 96 hours. The concentrations used during acute toxicity study with Ampicillin on *Clarias gariepinus* were 0.00mg/L, 500.00mg/L, 750.00mg/L, 1000.00mg/L, 1250.00mg/L and 1500.00mg/L respectively. Ten (10) fish were exposed to each concentration including the control in rectangular glass tanks containing dechlorinated water. Behavioural responses observed were startle response, agitated swimming, and vertical position. The LC_{50} values for Ampicillin = 13.29mg/L

Keywords: Toxicity, behaviour, ampicillin, catfish, juvenile

Introduction

Antibiotics are medicine that helps to stop infections caused by bacteria, either by killing the bacteria or by keeping them from copying themselves or reproducing. Antibiotics are a pharmacological agent that selectively kill or inhibit the growth of bacteria cells. Bacteriostatic Antibiotics prevent further replication of bacteria, and therefore rely on an intact immune system to clear the infection, whereas bactericidal antibiotics kill the bacteria. The use of bactericidal antibiotics is mandatory when treating infection (Sharon, 2007). Aquaculture sector has encountered serious setbacks such as mortalities emanating from

disease infections, mechanical injuries during transportation stress, sampling and sorting of fish (Romero *et al.*, 2012). Infectious diseases are always a hazard and may cause significant stock losses and problems with animal welfare. Intensive aquaculture (shrimp and fish farming) has led to growing problems with bacterial diseases, the treatment of which now requires the intensive use of antimicrobials. Although various authors have emphasized the putative negative effects of using antimicrobial agents in fish farms (Alderman and Hastings, 1998; Cabello, 2006). Few studies on antimicrobial resistance in the aquaculture industry have been performed *in situ*. (Fernández -Alarcón *et al.*, 2010). Ampicillin is frequently administered antibiotics both to the fish stocks and fish feed by aquaculturists (Isaac and Afisu, 2013). Most of them are not aware of the withdrawal period for the antibiotics nor the concentration to administer as well as its potential hazard to humans (Isaac and Afisu, 2013).

Materials and Methods

Fish and Antibiotics Sources

The Experimental site was located in Fisheries Laboratory, Modibbo Adama University, Yola. Adamawa State is located in the northeastern part of Nigeria with a population of 3,737,223 people and land mass of 36,917M² Yola. Adamawa State lies between latitudes 7- 11North of the Equator and longitudes 11-14 East of Nigeria.

Preparations of Test Solutions

The experiment is in two phases. The first phase is an acute toxicity study and the second phase is the sub-lethal study, each was conducted on *Clarias gareipinus* of mixed sexes and fairly uniform sizes, were obtained from Modibbo Adama University Fish Farm in Yola and transported in plastic containers to the laboratory in the Department of Fisheries, Modibbo Adama University, Yola. In the laboratory, the water from the farm was gradually replaced with De chlorinated tap water which was obtained by exposing the surface of the water for two days. Fish were acclimatized for two weeks. The fish were fed with a commercial feed (vital feed) (2 mm) twice a day (9.00 am and 5.00 pm). Feeding stopped 24 hours prior to the commencement of the experiment.

Pilot Study

Range finding tests were conducted to determine the concentrations of Ampicillin, Chloramphenicol and Tetracycline used for the definitive tests. It was carried out by introducing three concentrations into three separate test tanks (including the control) containing 20 liters of De-chlorinated water in triplicate. Ten fish each were introduced into each test tank and mortality of fish observed at 12, 24, 48, 72 and 96 hours. When 80% -90% of the fish died in the highest concentration test tank and 20 to 30% of fish died in the lowest concentrations test tanks and 20-30% of the fish died in the lower concentrations test tanks, the five nominal concentrations were then taken between the highest and the lowest concentrations geometrically.

Experimental design

Methods as Described by EPA (1996) and OECD.(1992) for acute toxicity tests .480 each of healthy juveniles of *Clarias gareipinus* of uniform weight and size were randomly sorted and distributed into, ninety sixty (96) plastic tanks Ten fish were sorted into each test tank including the control, and the tanks were replicated three times. Five nominal concentrations of the three antibiotics were used independently for the study.

Acute toxicity

Methods of acute toxicity tests as described by Sprague (1971) and APHA (1985) were followed. Range of concentrations of Ampicillin (500.750, 1000. 1250, and 1500 mg/L for *C. gareipinus* obtained in the pilot tests were dispensed with a pipette into 20 litres of de-chlorinated tap water of each test tank in triplicate. The mixture was undisturbed for ten minutes to allow for distribution by dilution.

Ten fish were exposed to concentrations of the toxicants in each test tank and the control tank had no toxicant. Water quality parameters such as temperature, dissolved oxygen, Conductivity and pH were monitored (APHA. 1985). The experiment lasted for 96 hours.

Behavioural studies

After exposure of the fish to various concentrations of the toxicants, observations will be carryout at 12, 24, 48, 72 and 96 hours according to (Drummond *et al.*, 1986) Control fish were also monitored along with the toxicant concentrations to provide a reference for assessing any behavior or morphological changes. Responses were recorded if they differed from the control and occurred in 10% of the fish in each test tank. The behavioural and morphological indicators to be observed include loss of equilibrium general activity, Tail Fin Movement, Startle responses, Air gulping, haemorrhage, and Vertical positioning. Each test tank will be observed for 3 to 5 minutes, Startle responses will be monitored by the following procedures, sequentially passing hand over the test tank (overhead moving visual stimulus), rapping on the tank (vibration stimulus), and lightly touching the fish with a wooden applicator stick (tactile stimulus) (Table 1).

Table 1: Behavioral Responses Monitored During Acute Toxicity Study

Air gulping	fish can be seen on the surface of water opening mouth
Vertical position	Fish occasionally assumed Vertical position before death
Loss of equilibrium	fish swim faster than the control fish around tank without being provoked at initial exposure time
Hemorrhage	fish can be seen with blood on the skin

Source: Adopted from Drummond *et al.*, (1986).

Observations of mortality rate of *C. gariepinus* juveniles were made at 12, 24, 48, 72 and 96 hours. Juveniles of *C. gariepinus* were considered dead when there was no sign of opercular movement or no response to external stimuli. The number of dead fish in each group was recorded against the time of their death in tabular form (Sprague, 1971). The dead fish were removed immediately to avoid dissolved oxygen depletion. The water temperature, dissolved oxygen, hydrogen ion concentration (pH) and conductivity were monitored throughout the duration of the experiment. Data generated were treated with descriptive statistics and regression analysis.

Results and Discussion

The results of Physico-Chemical parameters of diluting water during acute toxicity study with *C. gariepinus* exposed to Ampicillin shows that the mean values of temperature and dissolved oxygen (DO) exposed concentrations of 750 mg/L, 1000 mg/L, 1250 mg/L and 1500mg/L were significantly different with the Control, but less significant with 500 mg/L exposed fish (Table 2).

Table.2 Shows that the mean values of power of hydrogen ion (pH) concentrations of 1000mg/L, 1250 mg/L, 1500 mg/L were significantly higher than the exposed control fish, but less significant with 500 mg/L and 750 mg/L compared to the control.

Table 2: Some Physico-chemical Parameters of Diluting Water for *C. gariepinus* Juveniles Expose to Ampicillin at Various Concentrations in the Laboratory Monitor during Acute Experiment for 96 hours

Concentrations(mg/L)	Temperature (°C)	Dissolved oxygen (mg/L)	pH (power of hydrogen ion Conc.	Conductivity (Us m-L)
0.0	27.53±0.36 ^b	8.70±0.19 ^{ba}	7.60±0.06 ^a	148.13±17.18 ^{ba}
500	27.43±1.06 ^b	8.80±0.78 ^a	7.53±0.45 ^a	133.27±23.28 ^{ba}
750	28.70±1.11 ^a	7.93±0.89 ^c	7.27±0.47 ^{ba}	123.14±24.36 ^b
1000	28.50±1.14 ^{ba}	7.77±0.84 ^c	6.83±0.48 ^{bc}	150.93±25.02 ^a
1250	28.50±1.16 ^{ba}	5.83±0.85 ^d	6.63±0.49 ^c	143.73±25.44 ^{ba}
1500	28.50±1.18 ^{ba}	5.20±0.86 ^d	6.80±0.50 ^{bc}	148.23±25.76 ^{ba}

*Mean with different superscript along the column is significantly different ($P < 0.05$)

The behavioral response of *C. gariepinus* juveniles exposed to various concentrations of Ampicillin for 96 hours indicated that fish exhibited Air gulping, loss of equilibrium, Agitated swimming and vertical position which occurred in all the concentrations from 500,750,1000,1250 and 1500 mg/L. Hemorrhage was observed to be higher at higher concentrations.

Table 3: Percentage Cumulative Mortality Probit values of *Clarias gariepinus* Juveniles Exposed to Varying Concentrations of Ampicillin for 96 hrs

Treatment	Concentration (mg/l)	Log of concentration	% Mortality	Probit values
1	00	00	0.00	0.00
2	500	2.70	27.00	4.39
3	750	2.88	43.00	4.82
4	1000	3.00	57.00	5.18
5	1250	3.10	70.00	5.52
6	1500	3.18	80.00	5.84

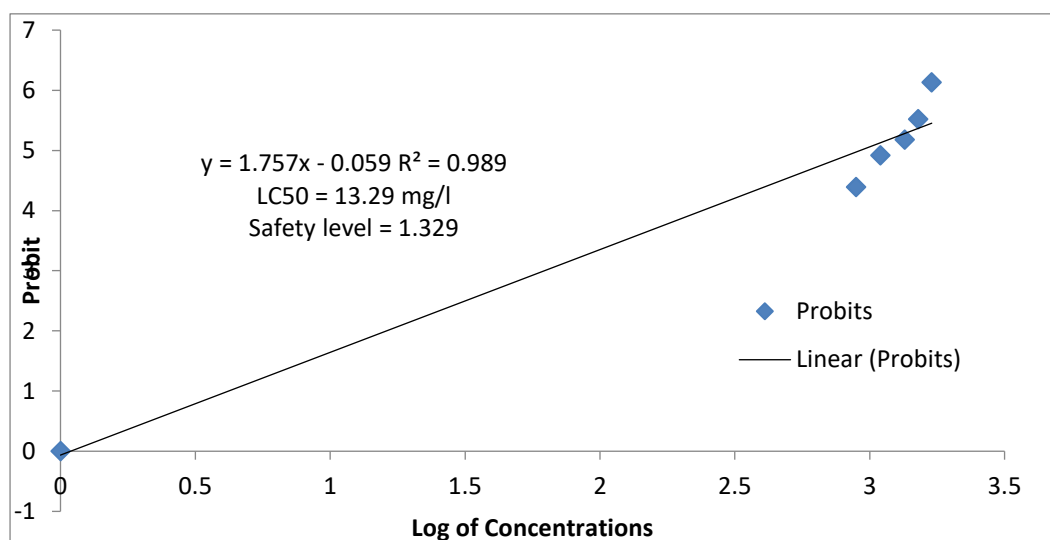


Figure 1: LC_{50} value of *C. gariepinus* Exposed to Acute Concentrations of Ampicillin

Water quality parameters had little variation, physicochemical parameter measured seemed to be slight within optimum range for fish culture as reported by Omitoyin *et al.* (2006) and Olaifa *et al.* (2003). The physio- chemical parameters of the water fluctuated slightly during the bioassay. This fluctuation was not enough to have caused the mortality. Death of test fish exposed to antibiotics may be attributed to the destruction of such organs as the gills, liver, kidney, brain, blood system and the pancreas. Limbu *et al.*, (2018) reported that gill tissues are most sensitive to water pollutants since gills are the primary site for osmo-regulation and respiration. They are highly vulnerable to lesions due to their immediate contact with aquatic pollutants while some pollutants enter the body; there is evidence that some of them exert their effects on the external surface of the fish especially the gills. The very high toxicity of the antibiotics could probably be attributed to some possible synergistic effect likely to be produced by the active ingredients in butachlor of which is the compound that exist separately as toxicant and likely to be equally toxic to fish (Limbu *et al.*, 2018).

Temperature, electrical conductivity, pH, dissolved oxygen and other physiological status of the experimental fish have profound effects, on the toxicity of the antibiotics. This is in agreement with the statement of Jaime *et al.*, (2012) on agro- chemicals. Fafioye *et al* (2011) also reported that toxicant affect gas exchange of fish and other aquatic organisms. This might probably be the reasons for the decline of dissolved oxygen concentrations as the concentrations of antibiotics increases. Because the water parameters

had little variation, this can be evident that physical and chemical properties of the water holding tanks were within the desirable range of fish culture (Nurea *et al.*, 2015).

The observed behavioural alterations in the *C. gariepinus* exposed fish indicate internal and external disturbances of the fish body system and may be attributed to neurotoxic effects of the drugs by Ampicillin, Chloramphenicol and Tetracycline inhibition, which remove the neuromuscular junction of the nervous system, thus affecting the normal functioning of the nerves (Miron *et al.*, 2005). Wang *et al.*, (2009) reported exposure of Asian catfish (*Pangasianodon hypophthalmus*) to enrofloxacin antibiotics severely depressed AChE activities in various organs of the fish, it has been observed that the inhibition of AChE was associated with disorders of respiration, swimming and feeding behavior .

The results of behavioural response of *C. gariepinus* exposed to Ampicillin, Chloramphenicol and Tetracycline for acute toxicity study showed that, fish exhibited air gulping, loss of equilibrium were observed at 12 and 24 hours. However, vertical positioning, hemorrhage and agitated swimming occurred at 48 and 72 hours. These behavioral responses were observed to be less frequent in Chloramphenicol and Ampicillin than in Tetracycline. Loss of equilibrium, vertical position and agitated swimming could be as a result of fish trying to escape from the toxic environment of the antibiotics. Air-gulping could be as a result of oxygen depletion in the exposed groups. Adeyemo (2015) reported a similar behaviour in *O. niloticus* exposed to Crude extract of *Raphia hookeri* fruits. Fafioye (2011) reported uncoordinated Swimming in bioassay media. Ali *et al.* (2014) observed this while presenting various reasons why drugs including antibiotics are used in fish farmed. Dan-Ologe *et al.* (2006) reported stem of *Euphorbia heterophylla*. Similar observation was also reported by Sogbesan and Ngadina, (2015) on *C. gariepinus* exposed to piscicidal plants. Mallum (2015) reported loss of equilibrium, uncoordinated swimming and haemorrhage in *C. gariepinus* exposed to Propanil.

Opercular and Tail fin beat counts of *C. gariepinus* and *O. niloticus* exposed to toxicants increased with the initial period of exposure at 12, 24 and 48 hrs. As the period of exposure increases from 72 to 96h, Opercular and Tailfin beat counts were observed to decrease in both Ampicillin, Chloramphenicol and Tetracycline. Fafioye (2011) reported uncoordinated swimming in *C. gariepinus*. Sogbesan and Ngadina, (2015) reported similar behavioural responses on *C. gariepinus* exposed to piscicidal plant.

The acute toxicity of the antibiotics to the fishes *Clarias gariepinus* showed that the mortality values are increasing as the concentration of the antibiotics also increases. This agrees with the study by Adedeji *et al.* (2015) investigated the effects of sub-lethal concentrations of glyphosate on mortality rates in *Clarias gariepinus*. The study found that as the concentration of glyphosate increased, mortality rates also increased. The findings of the study showed that the mortality of the fish species were dose dependent which were in line with the study by Adeogun *et al.* (2015) investigated the impact of lead exposure on mortality rates in *Clarias gariepinus*. The study found that as the concentration of lead increased, mortality rates also increased in the fish.

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TOXICITY OF AMPICILLIN ON *OREOCHROMIS NILOTICUS* (LINN.) JUVENILE

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Abstract

The research aimed to determine the acute effects of Ampicillin on behavioural responses, water quality and mortality *Oreochromis niloticus* Juveniles in static bioassay. The concentrations used during acute toxicity study with Ampicillin on *Oreochromis niloticus* were 0.00mg/L, 500.00mg/L, 750.00mg/L, 1000.00mg/L, 1250.00mg/L and 1500.00mg/L; respectively. Ten (10) fish were exposed to each concentration including the control in a rectangular glass tanks containing dechlorinated water. Behavioural responses observed were startle response, agitated swimming, and vertical position. The Lc50 values for Ampicillin = 13.29mg/L.

Keywords: Toxicity, Behavioral, Ampicillin, *Oreochromis niloticus*

Introduction

Antibiotics are medicine that helps to stop infections caused by bacteria, either by killing the bacteria or by keeping them from copying themselves or reproducing. Antibiotics are a pharmacological agent that selectively kill or inhibit the growth of bacteria cells. Bacteriostatic Antibiotics prevent further replication of bacteria, and therefore relay on an intake immune system to clear the infection, whereas bactericidal antibiotics kills the bacteria. The used of bactericidal antibiotics is mandatory when treating infection (Sharon, 2007). Aquaculture sector has encountered serious setbacks such as mortalities emanating from disease infections, mechanical injuries during transportation stress, sampling and sorting of fish (Romero *et al.*, 2012). Infectious diseases are always a hazard and may cause significant stock losses and problems with animal welfare. Intensive aquaculture (shrimp and fish farming) has led to growing problems with bacterial diseases, the treatment of which now requires the intensive use of antimicrobials. Although various authors have emphasized the putative negative effects of using antimicrobial agents in fish farms (Alderman and Hastings, 1998; Cabello, 2006). Few studies on antimicrobial resistance in the aquaculture industry have been performed *in situ*.(Fernández -Alarcón *et al.*, 2010). Ampicillin is frequently administered antibiotics both to the fish stocks and fish feed by aquaculturists (Isaac and Afisu, 2013). Most of them are not aware of the withdrawal period for the antibiotics nor the concentration to administer as well as its potential hazard to humans (Isaac and Afisu, 2013).

Materials and Methods

Fish and Antibiotics Sources

The Experimental site was located in Fisheries Laboratory, Modibbo Adama University, Yola. Adamawa State is located in the northeastern part of Nigeria with a population of 3,737,223 people and land mass of 36,917M2 Yola. Adamawa State lies between latitudes 7- 11North of the Equator and longitudes 11-14 East of Nigeria.

Preparations of Test Solutions

The experiment is in two phases. The first phase is an acute toxicity study and the second phase is the sub-lethal study, each was conducted on *Oreochromis niloticus*. of mixed sexes and fairly uniform sizes, were

obtained from Modibbo Adama University Fish Farm in Yola and transported in plastic containers to the laboratory in the Department of Fisheries, Modibbo Adama University, Yola. In the laboratory, the water from the farm was gradually replaced with De chlorinated tap water which was obtained by exposing the surface of the water for two days. Fish were acclimatized for two weeks. The fish were fed with a commercial feed (vital feed) (2 mm) twice a day (9.00 am and 5.00 pm). Feeding stopped 24 hours prior to the commencement of the experiment.

Pilot Study

Range finding tests were conducted to determine the concentrations of Ampicillin, Chloramphenicol and Tetracycline used for the definitive tests. It was carried out by introducing three concentrations into three separate test tanks (including the control) containing 20 litres of De-chlorinated water in triplicate. Ten fish each were introduced into each test tank and mortality of fish observed at 12, 24, 48, 72 and 96 hours. When 80% -90% of the fish died in the highest concentration test tank and 20 to 30% of fish died in the lowest concentrations test tanks and 20-30% of the fish died in the lower concentrations test tanks, the five nominal concentrations were then taken between the highest and the lowest concentrations geometrically.

Experimental design

Methods as Described by EPA (1996) and OECD.(1992) for acute toxicity tests 180 each of healthy juveniles of *Oreochromis niloticus* of uniform. eight and size were randomly sorted and distributed into, Eighteen (18) plastic tanks. Ten fish were sorted into each test tank including the control, and the tanks were replicated three times. Five nominal concentrations of the Ampicillin were used independently for the study.

Acute toxicity

Methods of acute toxicity tests as described by Sprague (1971) and APHA (1985) were followed. Range of concentrations of Ampicillin, 500.750, 1000. 1250, and 1500 mg/L for *O. niloticus* respectively obtained in the pilot tests were dispensed with a pipette into 20 litres of de-chlorinated tap water of each test tank in triplicate. The mixture was undisturbed for ten minutes to allow for distribution by dilution.

Ten fish were exposed to concentrations of the toxicants in each test tank and the control tank had no toxicant. Water quality parameters such as temperature, dissolved oxygen, Conductivity and pH were monitored (APHA. 1985). The experiment lasted for 96 hours.

Behavioural studies

After exposure of the fish to various concentrations of the toxicants, observations will be carryout at 12, 24, 48, 72 and 96 hours according to (Drummond *et al.*, 1986) Control fish were also monitored along with the toxicant concentrations to provide a reference for assessing any behavior or morphological changes. Responses were recorded if they differed from the control and occurred in 10% of the fish in each test tank. The behavioural and morphological indicators to be observed include loss of equilibrium general activity, Tail Fin Movement, Startle responses, Air gulping, haemorrhage, and Vertical positioning. Each test tank will be observed for 3 to 5 minutes, Startle responses will be monitored by the following procedures, sequentially passing hand over the test tank (overhead moving visual stimulus), rapping on the tank (vibration stimulus), and lightly touching the fish with a wooden applicator stick (tactile stimulus).

Table 1: Behavioral Responses Monitored During Acute Toxicity Study

Air gulping	fish can be seen on the surface of water opining mouth
Vertical position	Fish occasionally assumed Vertical position before death
Loss of equilibrium	fish swim faster than the control fish around tank without being provoked at initial exposure time
Hemorrhage	fish can be seen with blood on the skin

Source: Adopted from Drummond *et al.*, (1986)

Observations of mortality rate of *Oreochromis niloticus* juveniles were made at 12, 24, 48, 72 and 96 hours. Juveniles of *Oreochromis niloticus* were considered dead when there was no sign of opercular movement or

no response to external stimuli. The number of dead fish in each group was recorded against the time of their death in tabular form (Sprague, 1971). The dead fish were removed immediately to avoid dissolved oxygen depletion.

The water temperature, dissolved oxygen, hydrogen ion concentration (pH) and conductivity were monitored throughout the duration of the experiment. The data generated were subjected to descriptive statistics and regression analysis

Results and Discussion

The results of Physico-Chemical parameters of diluting water during acute toxicity study with *O. niloticus* exposed to Ampicillin shows that the mean values of temperature and dissolved oxygen (DO) exposed concentrations of 750 mg/L, 1000 mg/L, 1250 mg/L and 1500mg/L were significantly different with the Control, but less significant with 500 mg/L exposed fish (Table 2).

Table.2 Shows that the mean values of power of hydrogen ion (pH) concentrations of 1000mg/L, 1250 mg/L, 1500 mg/L were significantly higher than the exposed control fish, but less significant with 500 mg/L and 750 mg/L compared to the control.

Table 2: Some Physico-chemical Parameters of Diluting Water for *Oreochromis niloticus* Juveniles Expose to Ampicillin at Various Concentrations in the Laboratory Monitor during Acute Experiment for 96 hours

Concentrations(mg/L)	Temperature (°C)	Dissolved oxygen (mg/L)	pH (power of hydrogen ion Conc.	Conductivity (Us m-L)
0.0	27.53±0.36 ^b	8.70±0.19 ^{ba}	7.60±0.06 ^a	148.13±17.18 ^{ba}
500	27.43±1.06 ^b	8.80±0.78 ^a	7.53±0.45 ^a	133.27±23.28 ^{ba}
750	28.70±1.11 ^a	7.93±0.89 ^c	7.27±0.47 ^{ba}	123.14±24.36 ^b
1000	28.50±1.14 ^{ba}	7.77±0.84 ^c	6.83±0.48 ^{bc}	150.93±25.02 ^a
1250	28.50±1.16 ^{ba}	5.83±0.85 ^d	6.63±0.49 ^c	143.73±25.44 ^{ba}
1500	28.50±1.18 ^{ba}	5.20±0.86 ^d	6.80±0.50 ^{bc}	148.23±25.76 ^{ba}

*Mean with different superscript along the column is significantly different ($P < 0.05$)

The behavioral response of *O. niloticus* juveniles exposes to various concentrations of Ampicillin for 96 hours indicated that fish exhibited Air gulping, loss of equilibrium, Agitated swimming and vertical position which occurred in all the concentrations from 500,750,1000,1250 and 1500 mg/L for *O. niloticus*. Hemorrhage was observed to be higher at higher concentrations.

Table 3: Percentage Cumulative Mortality Probit Values of *Oreochromis niloticus* Fingerlings Exposed to Varying Concentrations of Ampicillin for 96 hrs

Treatment	Concentration (mg/l)	Log of concentration	% Mortality	Probit value
1	0	0.00	0.00	0.00
2	500	2.70	23.00	4.26
3	750	2.88	46.00	4.92
4	1000	3.00	56.00	5.18
5	1250	3.10	66.00	5.44
6	1500	3.18	78.00	5.84

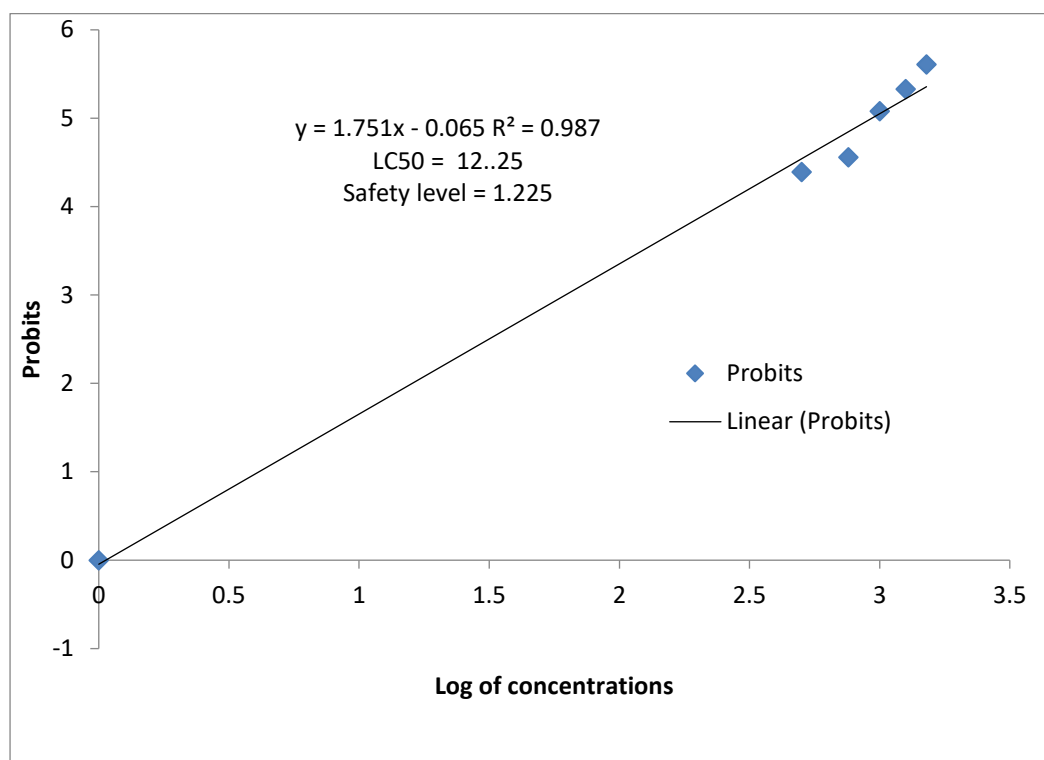


Figure 1: LC_{50} value of *O. niloticus* exposed to acute concentrations of Ampicillin

Water quality parameters had little variation, physicochemical parameter measured seemed to be slight within optimum range for fish culture as reported by Omitoyin *et al.* (2006) and Olaifa *et al.* (2003). The physio- chemical parameters of the water fluctuated slightly during the bioassay. This fluctuation was not enough to have caused the mortality. Death of test *O. niloticus* exposed to ampicillin may be attributed to the destruction of such organs as the gills, liver, kidney, brain, blood system and the pancreas. Limbu *et al.*, (2018) reported that gill tissues are most sensitive to water pollutants since gills are the primary site for osmo-regulation and respiration. They are highly vulnerable to lesions due to their immediate contact with aquatic pollutants while some pollutants enter the body; there is evidence that some of them exert their effects on the external surface of the fish especially the gills. The very high toxicity of the antibiotics could probably be attributed to some possible synergistic effect likely to be produced by the active ingredients in butachlor of which is the compound that exist separately as toxicant and likely to be equally toxic to fish (Limbu *et al.*, 2018). Temperature, electrical conductivity, pH, dissolved oxygen and other physiological status of the experimental fish have profound effects, on the toxicity of the antibiotics. This is in agreement with the statement of Jaime *et al.*, (2012) on agro- chemicals. Fafioye *et al* (2011) also reported that toxicant affect gas exchange of fish and other aquatic organisms. This might probably be the reasons for the decline of dissolved oxygen concentrations as the concentrations of antibiotics increases. Because the water parameters had little variation, this can be evident that physical and chemical properties of the water holding tanks were within the desirable range of fish culture (Nurea *et al.*, 2015).

The observed behavioural alterations in the *O. niloticus* exposed fish indicate internal and external disturbances of the fish body system and may be attributed to neurotoxic effects of the drugs by Ampicillin which remove the neuromuscular junction of the nervous system, thus affecting the normal functioning of the nerves (Miron *et al.*, 2005). Wang *et al.*, (2009) reported exposure of Tra catfish (*Pangasianodon hypophthalmus*) to enrofloxacin antibiotics severely depressed AChE activities in various organs of the fish, it has been observed that the inhibition of AChE was associated with disorders of respiration, swimming and feeding behavior (Payne *et al.*,). The acute toxicity of the ampicillin to *Oreochromis niloticus* showed that the mortality values are increasing as its concentrations increases. This agrees with the study by Adedeji *et al.* (2015).

The decreasing resistant of the fish species could be attributed to the inability of the fish supra-bronchial or accessory respiratory organ, composed of a paired pear shaped air-chamber containing two arborescent structures to withstand the chemical potency. This does not agree with the study of Auta *et al.*, (2000) that stated that since the air chamber communicates directly with the pharynx and the gill chamber, this accessory air breathing organ allows the fish to survive outside water for many hours or for many weeks in muddy marshes. The findings of the study showed that the mortality of the fish species were dose dependent which were in line with the study by Adeogun *et al.* (2015).

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LEAD (Pb) ACCUMULATION IN WATER, SEDIMENT AND DISTRIBUTION OF MACRO-INVERTEBRATES IN DELIMI RIVER, JOS, NIGERIA.

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ABSTRACT

This study assessed the concentrations of lead (Pb) in the water column and sediment as well as macro-invertebrates in River Delimi. Lead (Pb) levels were determined using Atomic Absorption Spectrometer (AAS) after extraction. Results showed that the concentration of lead (Pb) in all the water samples were found to be less than the permissible limit set by WHO/FAO except site WA3 (0.0874ppm) and WC3 (0.0678 ppm) which had higher than permissible limit. This implies that site WA3 and WC3 are not conducive for growth and survival of macro-invertebrates whereas other sites are safe. The concentration of lead (Pb) in sediment was higher than the WHO/FAO permissible limit in all sampling stations which is most likely to pose serious health risks to macrobenthos. However, statistical analysis shows that there is a significant variation ($P < 0.05$) in the concentrations of lead in water and Sediment. Also, 7 Micro-invertebrate taxa were identified in the sampling stations. Chironomidae, Eristalis Larva (Syrphidae), Tabanidae and Whirligig beetle (Gyrinidae) comprised more than 79% of the total abundance while stone fly Larva, hydrophilidae and beetle larva constituted the remaining. Dominance index of the above mentioned organisms suggest that station C was highly polluted and as are indicators of mesotrophic waters usually associated with high organic matter. Thus, restriction of the household, industrial and agricultural discharges to this River is required.

Key words: Lead (Pb), Water Column, Sediment, Macro-invertebrate, River Delimi.

INTRODUCTION

In the last two decades, Nigeria's modern cities have experienced an increase in industrial boom, urban migration and also increased human and vehicular activities (Orisakwe, 2017). These activities increase environmental pollution through the release of toxic substances into the atmosphere and have resulted in sundry contaminants in agricultural soils (Orisakwe, 2017). The pollution of soil, atmosphere and water bodies by toxic metals can be persistent and irreversible (Wang, Dong, Cui & Liu, 2001). The presence of certain metals such as lead (Pb), cadmium (Cd) and mercury (Hg) in the environment is of public health concern when their concentrations are higher than permissible concentration set by WHO/FAO, USEPA and EU in different matrices (Fakhri, Mohseni & Jafarzadeh, 2015; Ahmad, Mushrifah & Othman, 2009). Exposure to lead (Pb) occurs mainly via inhalation and ingestion from contaminated foods, which may pose threat to human health especially children who may suffer a high health risk (elevated Blood Lead Level) due to the bio accumulative potential (Luo, Yu, Zhu & Li, 2012; Hu, Sun & Ding, 2014). Natural and anthropogenic activities in urban cities which include mining, smelting, industrial emission, waste incineration, coal burning and vehicle exhaust emission are sources of lead (Pb) pollution in the environment (Charlesworth, De Miguel & Ordonez, 2011; Wei & Yang, 2010). Exposure to Lead among populations living in developing countries occur primarily due to economic and social vulnerability when they engage in informal activities (waste recycling and crude mining) that release Lead (Pb) into the environment (Pascale, Sosa & Bares, 2016). Unlike in developed countries, the majority of the populations in Nigeria are unaware of the toxic effects of Lead (Pb) exposure hence the population is at high risk. It has been established that most of the solid waste generated in the city is dumped in the rivers (Farooq & Umar 2008). According to Abdullahi, Uzairu, & Okunota (2009), River Delimi and Jenta are the major source of water for irrigation in and around the Jos city. These rivers contain a substantial amount of beneficial nutrients and toxic heavy metals, which creates opportunities and problems for agricultural production. The aquatic environment is heavily degraded due to various anthropogenic activities that cause domestic and industrial effluents particularly rivers, lakes, and the reservoirs (aquatic ecosystem) located near industrial and urban areas are the potential target for the disposal of the environmentally harmful elements like organic and inorganic contaminants (Kamaludeen et al., 2003). Thus a comprehensive health risk assessment of agricultural soils in this region is urgently needed, to assess the level of soil pollution by Lead (Pb) due to mining activities.

Heavy metals are of particular concern due to their non-biodegradable nature and their detrimental effect to the human health. These heavy metals have a high ability to bio-accumulate in various organs and muscle tissue of fish (DeForest, Brix & Adams, 2007). In the aquatic environment trace elements are distributed between dissolved phase, colloids, suspended matter and sedimentary phases. In the hydrological cycle, less than 0.1% of the metals are actually dissolved in the water and more than 99.9% are stored in sediments and soils (Pradit, Wattayakorn, Angsupanich, Leemaker & Baeyens, 2010). Human activities such as mining, manufacturing and fossil fuel burning has resulted in the accumulation of Lead and its compounds in the environment, including air, water and soil (Jaishankar, 2014). Lead is used for the production of batteries, cosmetics, metal products such as ammunitions, solder and pipes among others (Martin & Griswold, 2009). Lead is highly toxic and hence its use in various products, such as paints, gasoline among others and has been considerably reduced nowadays. The main sources of Lead exposure are Lead (Pb) based paints, gasoline, cosmetics, toys, household dust, contaminated soil, industrial emissions (Gerhardsson, Dahlin, Knebel & Schutz, 2002). Acute exposure mainly occurs in the place of work and in some manufacturing industries which make use of lead (Jaishankar, 2014). Chronic exposure of lead can result in mental retardation, birth defects, psychosis, autism, allergies, dyslexia, weight loss, hyperactivity, muscular weakness, brain damage, kidney damage and may even cause death (Jaishankar, 2014). Lead (Pb) is a pervasive environmental contaminant and the adverse health effects of lead (Pb) exposure in children and adults are well documented but no safe blood lead threshold in children has been identified (Brown & Margolis, 2012).

Benthic macroinvertebrate assemblages contain species with various sensitivities to contaminants and have been widely used to evaluate the ecological impacts of metal contamination in streams (Maret, Cain, MacCoy & Short, 2003). Metal contamination can reduce benthic macro invertebrate species richness, as well as density, growth and production (Gray & Delaney, 2008). The effects of heavy metals on macro-invertebrates are highly

variable among taxa and may also have an effect on ecosystem function. Clements (1999) recorded a change in functional feeding groups (FFG) of benthic macro invertebrates with lower abundances of scrapers, shredders, collectors, and predators at stations with medium and high-concentrations of heavy metals, compared with reference stations. Benthic macro-invertebrates however, were found to be more sensitive to heavy metals at higher elevations (Clements, 1999).

MATERIALS AND METHODS

Study area

This study was conducted at River Delimi of Jos-North local government of Plateau State. Water from this River is used for domestic purposes and irrigation.

Jos-North Local government area is located at the extreme north of Plateau State on latitude $09^{\circ} 53'$ and $09^{\circ} 05'$ North, and Longitude $08^{\circ} 51'$ and $09^{\circ} 02'$ East. It shares boundary to the North with Toro local government of Bauchi State; to the South with Jos South local government area; to the North-East with Jos- East local government area, and to the West with Bassa local government.

Jos- North local government enjoys a temperate climate with average temperature of between 11°C minimum and 28°C maximum. It covers the total land area of 291km^2 . Jos-North local government is characterized by a mean annual rainfall of between 1317.5mm (131.75cm) and 1460.00mm (146cm), mostly in May to August.

Collection and preparation of samples

Water Samples were collected from October to November 2019 from predetermined sampling points which were designated station A, B and C. The water samples were collected in 250 ml capacity plastic bottles with screw caps at 30cm depth. The plastic bottles had previously been washed and finally rinsed using distilled water. Total 36 sediment samples were collected from station A, B and C from October- November 2019 as described in Table 2. The sampling distance from one station to another was at least about 2km. The sample mass collected were in airtight polythene bags measuring 500g each. Sub-samples of the material were sun-dried for three (3) days, the dried samples were homogenized by grinding in laboratory mortar and pestle and sieved (aperture $125\mu\text{m}$) then stored in glass bottles for chemical analyses. Physicochemical parameters of the water were monitored from each sampling station using the methods described by (APHA,2005).

Determination of lead(pb) concentration in samples

Total concentrations of lead (Pb) in water and sediment samples were determined by using an atomic absorption spectrophotometer (AAS), equipped with single elements hollow-cathode lamps at the wavelengths of 324.7, 213.9, 283.3, 228.8, 232.0 and 357.9 nm, respectively. Lamp intensity and band pass were used according to the manufacturer's recommendations. For the determination of total heavy metal concentration in sediment, exactly 1.00 g of powdered sediment sample was digested with aqua regia ($\text{HNO}_3 : \text{HCl} = 1: 3$). Before use, all glass and plastic ware were soaked in 14% HNO_3 for 24 hrs. The washing was completed with a distilled water rinse.

Identification of Macro-Invertebrates - These were identified using the Identification guide to Freshwater Macroinvertebrates as described by Stroud Water Research Center.

Data Analyses - This was calculated using the one-way analysis of variance (ANOVA) was used to determine whether there are any statistically significant differences between the means of the samples collected from the three locations in the study area.

RESULTS AND DISCUSSION

Water quality results of the three sampled stations are as shown in Table 1. Station (C) has higher mean values as compared to others but for pH (5.40 ± 0.1) and Dissolved Oxygen (4.20 ± 0.1) whose values are indicative of some level of pollution.

Table 1

Mean water quality parameters monitored during the experimental period

Parameter	Station A	Station B	Station C
Temperature ($^{\circ}\text{C}$)	22.50 ± 0.1	22.00 ± 0.3	23.00 ± 0.1
pH	7.90 ± 0.2	6.50 ± 0.1	5.40 ± 0.1
Dissolved oxygen (mg/L)	11.20 ± 0.1	9.50 ± 0.2	4.20 ± 0.1
Free carbon dioxide (mg/L)	90.00 ± 0.2	100.00 ± 0.2	120.80 ± 0.4
Alkalinity(mg/L)	50.00 ± 0.1	66.00 ± 0.3	136.00 ± 0.5

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Level of pb in station A ranged between 0.0085-0.0874, in station B it was 0.0085-0.0339 while station C ranged between 0.0085 - 0.0678

Table 2

Concentration (ppm) of Lead (pb) in water column of River Delimi

Sampling Period	Sampling Stations								
	Station A			Station B			Station C		
	WA1	WA2	WA3	WB1	WB2	WB3	WC1	WC2	WC3
07/10/19	0.0455	0.0315	0.0874	0.0105	0.0245	0.0315	0.0245	0.0245	0.0455
21/10/19	0.0085	0.0339	0.0424	0.0169	0.0339	0.0085	0.0508	0.0085	0.0678
04/11/19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
18/11/19	0.0588	0.0588	0.0392	0.0000	0.0339	0.0294	0.0392	0.0490	0.0392

Sediment concentrations in Station A ranged between 7.63-240.26, Station B was 12.29-154.90 while 29.66-665.69 was in Station C

Table 3

Concentration (ppm) of lead (pb) in sediment of River Delimi in two(2) months

Sampling Period	Sampling Stations								
	Station A			Station B			Station C		
	A1	A2	A3	B1	B2	B3	C1	C2	C3
07/10/19	25.85	19.07	7.63	12.29	15.25	17.37	31.36	29.66	34.32
21/10/19	91.53	43.22	60.17	32.20	40.68	54.24	38.14	39.83	123.20
04/11/19	128.32	201.77	240.26	84.07	125.66	80.53	58.41	570.80	120.35
18/11/19	43.14	47.06	143.14	33.33	49.02	154.90	418.63	665.69	88.24

Four orders of Macro-invertebrates were identified and their tolerant values ranged from 0-18 i.e from highly sensitive - highly tolerant to changes in the environment.

Table 4. Species composition, abundance and distribution of Macro-invertebrates in River Delimi.

Order	Family	Taxa	Stations			Pollution Status
			A	B	C	
Coleoptera	Dysticidae	<i>Phylodyte Sp</i>	0	0	10	Very tolerant
	Hydrophilidae	<i>Crenis Sp</i>	5	6	0	Sensitive
	Tabanidae	<i>Tabanus Sp</i>	0	0	4	Tolerant
Diptera	Chironomidae	<i>Chironomus Sp</i>	0	2	18	Very tolerant
	Syrphidae	<i>Unknown Sp</i>	0	4	14	Very tolerant
Ephemeroptera	Gyrinidae	<i>Orectochilus Sp</i>	4	6	0	Sensitive
Plecoptera			0	0	12	Very tolerant

The water quality characteristics revealed that temperature ranged between 22.00-23.00°C with the value of station C higher than station A and B, pH ranged 5.40-7.90g/L with station C having lowest value than station A and B. The low pH (below 7) in water collected at station B and C indicated that it is slightly acidic. Dissolved oxygen ranged from 4.20-11.20mg/L indicating higher dissolved oxygen in station A and B than station C, free carbon dioxide ranged from 90.00-120.00mg/L with station C having higher value than station A and B while alkalinity ranged 50.00-136.00mg/L with station A having lower value (50.00 mg/L) than station B (66.00 mg/L) and C (136.00 mg/L) respectively. Earlier studies by Absalom *et al* (2005) recorded similar values while studying the Coliform, Planktonic and Macro-invertebrates of this river.

Anthropogenic activities like mining, farming and indiscriminate refuse dumping alter the clean water and soil composition and are considered one of the most significant sources of Lead(Pb) pollution in rivers (Acosta et al.,

2011; Zhuang et al., 2009). The local residents living around Abattoir, British America and Farin Gada communities mainly engage in farming and artisanal mining as part of their occupation. The three (3) communities showed diverse concentration of lead (Pb) in water of river Delimi. as shown in Table 2, the mean lead concentrations in water collected from the three Sites ranged from 0.0085 – 0.0874 ppm with highest concentrations in WA3 (Abattoir) and WC3 (Farin Gada) with values higher than the permissible limit of 0.05ppm provided by WHO/FAO which is in agreement with Farooq and Umar (2008). Concentrations were lower in WA1 (Abattoir) as well as WB1 (British America) while the third sampling showed no trace of Lead (Pb) in all the locations. However, their means showed some variation.

A study carried out by (Saboet al.,2013) suggested that dumping of different waste materials such as plastics, electrical and electronic materials, metal scraps, old batteries, spent lubricating oil from nearby mechanic workshops along the Delimi River bank may be responsible for the high level of heavy metals in the river water. Although sediment have heavy metal immobilizing capability, the ability of metals to bio-accumulate over a period of time will result in uptake by benthic organisms in the contaminated soils. Since Lead (Pb) is not very mobile in soil (US ASTDR, 2010), concentrations of lead in soil which are representative of the degree of pollution/contamination may not directly be linked to an adverse health effect without conducting a health risk assessment of the organisms, because only a fraction is taken up by the organisms. The bioavailable metal content in water and soil exerts a significant impact on water quality and this might affect food safety and biodiversity of macro invertebrates. Hence, the assessment of heavy metal contamination is of public health importance in agricultural soils (Loska et al., 2004). The disparity in concentration observed in the studies could be as a result of the different contamination source. The increase in Blood Lead Level(BLL) among Nigerians may not be unconnected to environmental Lead (Pb) emission from industries, mines and leaded gasoline due to limited regulatory restrictions from the relevant government agencies to check pollution. Lead (Pb) accumulates in sediment and can pose a hazard to sediment dwelling organisms at concentration above 30.2ppm according to Canadian interim marine sediment quality guideline.

A total of 7 taxa were identified in the three (3) sampling stations of River Delimi. Chironomidae, *Eristalis* Larva (Syrphidae), Tabanidae and Whirligig beetle (*Gyrinidae*) comprised more than 79% of the total abundance, while stonefly Larva, Hydrophilid beetle and beetle larva (*Coleoptera*) constitute 21% of the total abundance, respectively. As seen in table 4, it will be observed that only two (2) taxa (hydrophilid beetle and whirling beetle) were found in station A implying moderate water quality of the station. While the presence of *Eristalis* larva and *Chironomus* larva though in low index suggest that station B is slightly polluted. The high dominance index of *Chironomus* larva and *Eristalis* larva indicates that station C were instable causing imbalance of ecosystem. Usually certain organism like *Chironomus* sp. can thrive in an environment with high organic contamination. Most Chironomidae larvae are efficient indicators of mesotrophic waters, and these are usually found at location having high decomposed organic matter. Thus, presence of the Chironomidae family by higher percentage reflected that station C was highly polluted. According to Absalom *et al* (2005); Mariantika and Retnaningdyah (2014), *Chironomus* species are indicator of waters contaminated by high load of organic waste. According to Setiawan (2009), Studying macro-invertebrate diversity is one of the most effective and inexpensive ways to estimate the ecological quality of the waters. For example, measurements of the physical and chemical properties of water can also be used to estimate its quality but such measurements cannot exactly represent its actual state. Therefore it is necessary to combine physical, chemical, and biological evaluation along with other monitoring methods to provide a comprehensive picture of environmental water quality (United States Environmental Protection Agency, (2018)). Biological monitoring using macro-invertebrates has been found accurate and advantageous compared with using other organisms because macro-invertebrates are extremely sensitive to organic pollutants, widely distributed, and easy and economical to sample (Setiawan, 2009).

Conclusion

In conclusion, Delimi River received certain pollutants and can be categorized as a polluted river. Hu *et al.* (2014), described numerous sources of Lead (Pb) as sewage sludge, leaded gasoline from vehicular traffic and industrial emission, but recent studies have shown that mining could be a major source point of Lead (Pb) pollution in agricultural soils. The high level of Lead in sediment suggests that sediment dwelling organisms are likely to bio accumulate Lead over time. This study also provides insights on the impacts of environmental variables on the diversity of macro-invertebrate assemblage in River Delimi. Given the negative effects of Lead (Pb) consumption

on human lives and macro-invertebrates, the study recommended that: government should enforce the ever existing law that bans dumping of refuse, sewage and industrial waste into rivers. Restriction of human, industrial and agricultural discharges to this River is required with continuous monitoring to ensure that the concentrations of Lead remain within the prescribed worldwide limits to protect it from further deterioration.

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FISH BIOLOGY

FISH ABUNDANCE AND DIVERSITY OF TATABU FLOOD PLAIN IN MUWO DISTRICT, MOKWA LOCAL GOVERNMENT AREA, NIGER STATE

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Abstract

Fish samples were collected from artisanal fishermen and middlemen at landing sites from January 2021 to March 2021. The fishermen uses wide ranges of fishing gears such as gillnets, hook and line and traps. The collected fish samples were sorted and identified to families, genera and species levels. A total of (28) fish species belonging to (14) families was recorded. The highest fish diversity was found in the family Cichlidae and Mochokidae with (6) species each, followed by Mormyridae with (4) species and Bagridae with (2) species, though family Alestidae, Centropomidae, Channidae, Clariidae, Clarotidae, Cyprinidae, Gymnarchidae, Osteoglossidae, Protopteridae and Schilbeidae recorded lowest diversity with (1) species each. *Coptodon zilli* was found to be the most abundant fish species (18.15%) in Tatabu flood plain during the study period, followed by *Sarotherodon galilaeus* (15.06%) and *Synodontis shall* (11.58%), While the less abundant fish species are *Parachanna obscura*, *Labeo senegalensis*, *Synodontis punctifer* and *Protopterus annectens* with (0.39%) each. The diversity of Tatabu Flood plain is slightly low when compared to the work of Yem *et al.* (2019), which was carry out during rainy season with the diversity of (31) species of fish from (13) families. This finding is contrary to the findings of Daddy *et al.* (1991) where 71 species of fish was found in Tatabu flood plain.

Key words: Tatabu flood plains, Family, Specie, Abundance, Diversity.

Introduction

Fish has become an acceptable source of animal protein in most regions of the world in recent times, and of which the inland artisanal capture fishery contributes significantly to the national food requirements and economics, making up to 85 to 90% of domestic production. In addition, the inland fishery, which is based on exploitation of the rivers, reservoirs, lakes fishponds and flood plains, provides economic support and livelihood in rural areas where 70% of the Nigerian population lives (Dugan, 1990).

In its natural state flood plains provide nutrient-rich., sheltered habitats used by fish for spawning, nursery areas and good habitat for adult fishes. Apart from fishes that are endemic to flood plains some other commercially important species require seasonally flooded grounds. More than two-thirds of the fish we eat depend upon flood plain at some stage in their life cycle (Dugan, 1990). Several other studies (Welcomme, 1975, Awachie, 1976) have shown that Nigerian flood plains have tremendous fishery productivity sustaining the human population built around them. But in recent times, the increasing intensive and indiscriminate exploitation by the rapidly expanding human population have adversely altered flood plain ecology with consequence on its fisheries. When combined with natural stresses such as droughts, have resulted in reduced productivity and low carrying capacity. And yet adequate scientific information on most of the flood plains are scanty to ensure long-term sustainability of fishery resources at levels which promote optimum utilization and maintaining availability for present and future generation. This study attempts to document fish abundance and diversity of Tatabu flood plain.

Materials and Methods

The study area is located between longitude 40 52' E to 40 47' E and latitude 90 16' N to 90 18' N in northern Nigeria. It is situated between Kainji and Jebba Dams. Muwo district is a village in Mokwa Local Government Area of Niger State (plate 1). The climate of the study area can be described as hot equatorial climate with high temperatures with an average daily maximum of 33.5°C in the warmest month. The difference in the river water level is controlled by the inflow of water from the Kainji hydro power plant. Rainfall in the area is about 1071mm. The river of the area is dammed at Jebba Hydro power plant (Olaniyan *et al.*, 2010). The fish samples were collected from artisanal fishermen and middlemen at landing sites. The

fishermen uses wide ranges of fishing gears such as gillnets, (1', 1½', 2', 2½', 3', 3½', 4', 5' and 7') hook and line and traps. The collected fish samples were sorted and identified to families, genera and species levels, using the identification keys of Reed *et al.* (1967) and Olaosebikan and Raji (2021). The identified species were weighed to the nearest 0.1g using weighing balance and standard lengths were determined to the nearest 0.1mm using measuring board and recorded on data record sheet.

Data generated were presented in percentage and graphs.

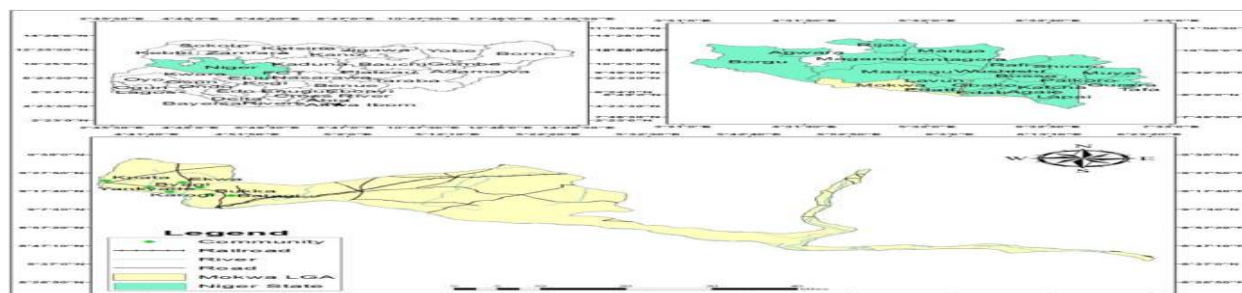


Plate 1: Map of Tatabu flood plain

RESULTS AND DISCUSSIONS

Table 1 record a total of (28) fish species belonging to (14) families. The highest fish diversity was found in the family Cichlidae and Mochokidae with (6) species each, followed Mormyridae with (4) species and Bagridae with (2) species thought family Alestidae, Centropomidae, Channidae, Clariidae, Clarotidae, Cyprinidae, Gymnarchidae, Osteoglossidae, Protopteridae and Schilbeidae recorded lowest diversity with (1) species each. The difference in diversity may be due to the fishing methods, activities going around or nature of the water body, neither static nor stable or could be the sampling period which is dry season. *Coptodon zilli* was found to be the most abundant fish species (18.15%) in Tatabu flood plain during the study period, followed by *Sarotherondon galilaeus* (15.06%), and *Synodontis shall* (11.58%), While the less abundant fish species are *Parachanna obscura*, *Labeo senegalensis*, *Synodontis punctifer* and *Protopterus annectens* with (0.39%) each. The diversity of Tatabu Flood plain is slightly lower when compared to the work of Yem *et al.* (2019), which was carry out during rainy season with the diversity of (31) species of fish from (13) families. This finding is contrary to the findings of Daddy *et al.* (1991) where 71 species of fish was found in Tatabu flood plain.



Chromidon tilapiaquenterhi



Schilbe intermediat



Bagrusbayad



Parachanna obscura



Tilapia dageti



Synodontis eupterus



Synodontis nigrita



Synodontis shall



Alestes bariums



Gnathonemus senegalensis



Oreochromis niloticus



Sarotherodon galilious



Clarias angularis



Auchenoglanis occidentalis



Synodontis punctifer



Synodontis ocellifer



Protopterus annectens



Synodontis membranaceus



Labeo senegalensis



Lates niloticus



Mormyrops anguilloides



Hyperopisus bebe



Coptodon zilli



Mormyrus rume



Proceedings of the 37th Annual Conference of FISON

Clarote laticep

Heterotis niloticus

Gymnarchus niloticus



Hemichromis fasciatus

Table 1: Fish Diversity and Abundance of Tatafu Flood Plain

Family /Species	No	%No	Wt	%Wt
Alestidae				
<i>Alestes bariums</i>	3	1.16	300	0.57
Bagridae				
<i>Auchenoglanis occidentalis</i>	3	1.16	1870	3.58
<i>Bagrus bayad</i>	12	4.63	3850	7.38
Centropomidae				
<i>Lates niloticus</i>	9	3.47	8400	16.09
Channidae				
<i>Parachanna obscura</i>	1	0.39	100	0.19
Cichlidae				
<i>Sarotherodon galilaeus</i>	39	15.06	10800	20.69
<i>Chromidon tilapiaguenterhi</i>	5	1.93	500	0.96
<i>Coptodon zilli</i>	47	18.15	3485	6.68
<i>Tilapia dageti</i>	2	0.77	1960	3.76
<i>Hemichromis fasciatus</i>	4	1.54	250	0.48
<i>Oreochromis niloticus</i>	24	9.27	4600	8.81
Clariidae				
<i>Clarias angularis</i>	3	1.16	1350	2.59
Clarotidae				
<i>Clarote laticep</i>	16	6.18	1600	3.07
Cyprinidae				
<i>Labeo senegalensis</i>	1	0.39	250	0.48
Gymnarchidae				
<i>Gymnarchus niloticus</i>	2	0.77	6	0.01
Mochokidae				
<i>Synodontis membranaceus</i>	4	1.54	1200	2.30
<i>Synodontis occilifer</i>	6	2.32	500	0.96
<i>Synodontis nigrita</i>	8	3.09	450	0.86
<i>Synodontis shall</i>	30	11.58	2050	3.93
<i>Synodontis eupterus</i>	2	0.77	100	0.19
<i>Synodontis punciifer</i>	1	0.39	50	0.10
Mormyridae				
<i>Hyperopisu sbebe</i>	4	1.54	710	1.36
<i>Gnathonemus senegalensis</i>	3	1.16	410	0.79
<i>Mormyrus rume</i>	5	1.93	750	1.44
<i>Mormyrop sanguloides</i>	8	3.09	1900	3.64
Osteoglossidae				
<i>Heterotis niloticus</i>	7	2.70	3450	6.61
Protopteridae				
<i>Protopterus annectens</i>	1	0.39	400	0.77
Schilbeidae				
<i>Schilbe</i>	intermediat 9	3.47	900	1.72

Total	259	100.00%	52191	100.00%

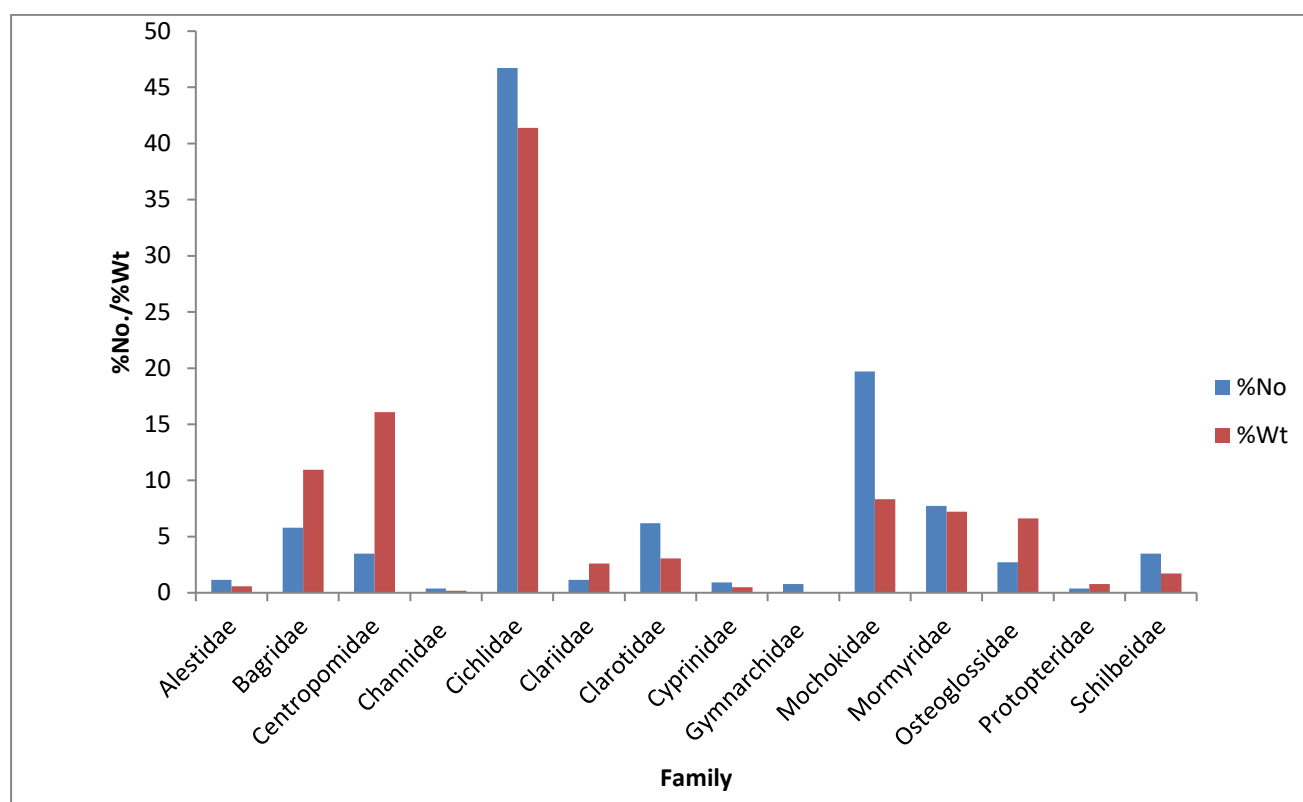


Figure 1: Percentage Number and Weight of Fish Families in Tatabu Flood Plain

Figure 1 shows that family Cichlidae recorded the highest percentage number of fish from Tatabu flood plain with (46.72%) follow by the family Mochokidaein accounted (19.69%) and family Channidae recorded lowest percentage number of fish with (0.39%) while in terms of weight the family Cichlidae also has the highest percentage weight recorded (41.38%) and the family Gymnarchidae accounted least weight with (0.01%).

Conclusion and Recommendation

Tatabu flood plain, show a slight depletion of the fish species diversity as reveal with the current study, when compare to other works done on the water body. Constant monitoring and management of Tatabu food plain need to be put in place to control this gradual decline of fish species.

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BIOLOGICAL CONDITION OF BAYAD (*Bagrus bajad*, FORSSKAL 1775) IN RIVER WUDIL, KANO, NORTHWEST, NIGERIA

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ABSTRACT

The biological condition of bayad (*Bagrus bajad*) in river Wudil, Kano State, Nigeria, was assessed using the length-weight relationship and condition factor. One hundred and sixty-five pieces comprising of 85 males and 80 females were collected from fishermen. Descriptive statistic was used to present the morphometric data, while linear regression was used to analyse the length-weight relationship and the sex ratio across stages was assessed with student's t-test. The b value obtained was used in computing the condition factor. The results showed *B. bajad* from the river had weight ranged between 19.50 and 133.57 g, and the standard length between 11.50 and 24.50 cm. All the fish examined had negative allometric growth, b value less than 3. However, the condition factor was either very close or higher than one for any of the category, indicating the fish in the water are all healthy and the environment is favourable irrespective of the sex. The coefficient of determination for the regression lines are 0.9858, 0.9813 and 0.9846 for males, females and combined sex respectively. The coefficients of determination were strong and significant, indicating that the b value and predicted equations are very reliable. The distribution of the sample showed almost 70% of the fish are not matured yet, it indicates a water body with great potential. However, it is important to put in place proper management practices to ensure the sustainability of the stock.

Keywords: Biological condition, condition factor, growth exponent, *Bagrus bajad*, river Wudil

INTRODUCTION

Fish is a natural resource of immense benefit to man, it is a source of cheap but quality animal protein (Dauda, 2014). It has been a primary source of animal protein to the dwellers of coastal towns and villages, as well as riverine areas. Ajani *et al.* (2008) reported that 49% of animal protein consumed in Nigeria is fish, a greater percentage of the fish consumed in Nigeria are from capture fisheries (Dauda, 2014). Atobatele & Ugwumba (2008) noted that there are wide varieties of aquatic organisms in Nigeria inland water bodies. These include the vertebrates such as fish, crocodiles and aquatic mammals, non-vertebrates such as crustaceans and sessile organisms, the aquatic macrophytes and planktons, with various interactions among the organisms in any aquatic ecosystem. Fish like any other organisms are affected by the activities in their environment, their growth *in situ* is affected by the fluctuations in the environmental factors, such as climatic

factors and anthropogenic activities that may influence the food composition and availability, and even the well-being of the fish species in the water body (Jenyo-Oni *et al.*, 2014). Factors such as pollution, eutrophication and fishing are among the previously documented factors that could affect the species composition, size and abundance of fish in the aquatic environment (Welcomme, 2001). Growth in fish like other organisms could be defined as the change in length and weight over a period. It can also be defined as the change in the number with time in the case of the population (Abowei & Ezekiel, 2013). According to Welcomme (2001), factors influencing fish growth could be classified as endogenous and exogenous. Endogeneous factors include genetic components of fish which may influence the growth rate and attainable maximum size for different species. The exogenous factors include the availability of suitable food organisms, feeding rate, nature and quality of food ingested. Effective management of natural water bodies can only be done successfully with adequate knowledge of the biological condition of fish species in the water bodies (Jenyo-Oni *et al.*, 2014; Ude *et al.*, 2011). Length-weight relationships and condition factor are the major indices for estimating the biological condition of fish and they are very important in the study of fisheries biology (Imam *et al.*, 2010). The condition factor (K) is highly influenced by both biotic and abiotic factors and it has been used over time for the assessment of healthiness of aquatic ecosystem to fish species in the ecosystem (Adeyemi *et al.*, 2009). The length-weight relationship is of importance in stock assessment and can be used to estimate the stock biomass and comparing fish population from different regions (Ayoade & Ikulala, 2007). A value of K equal to one or greater than one is said to be good for fish species and the aquatic ecosystem is assumed to be healthy for fish. The environment with K less than one is said not to be suitable. The length-weight relationship shows the growth pattern and it also reveals the growth exponent of fish (Bala *et al.*, 2009). Fish generally have two growth pattern namely isometric and allometric growth. Isometric growth shows an equal proportion of growth in weight and length and the growth exponent, while allometric growth shows the different growth rate in length and weight and b value is not equal 3 (Jenyo-Oni *et al.*, 2014). Positive allometric growth is reported when b is greater than 3, while b less than 3 indicates a negative allometric growth. Several researchers have worked on length-weight relationship of different fish species in Nigeria water bodies, these include, Jenyo-Oni *et al.* (2014) on lower Ogun river wetlands, Ude *et al.* (2011) on fish species of Ebonyi river, Bala *et al.* (2009) on the ichthyofauna of Daberam reservoir, Katsina, Imam *et al.*, (2020) on four species of Wasai river, Kano, among others. Bayad, also known as silver catfish is an important fish from the family Bagridae. It is among the most abundant fish species in water bodies of the North-western part of Nigeria. It has been noted as the most abundant fish species in Zobe reservoir, Katsina State (Dasuki *et al.*, 2014). Its contribution to fisheries activities in the region can not be overemphasized, it is, therefore, important to be properly informed of its well-being in water bodies in the region. This study aimed at assessing the biological condition of *B. bajad* in river Wudil, Kano State, to understand its status and well-being.

MATERIALS AND METHODS

Study Area

Wudil Local Government Area of Kano state is 44 km away from Kano city, it is along Maiduguri road, and also the link to Gombe, Yola, Jigawa and Bauchi states and its coordinates are latitude 11° 49'N and longitude 8° 51' E (Figure 1). Fishing and sand mining are notable occupations of people of Wudil, due to the presence of River Wudil. It has an area of 362 km² and a population of 185,189 at the 2006 census. River Wudil is also a tributary of River Hadejia which gets its water from River Challawa and River Kano and their tributaries, and flows northeast as River Hadejia and finally into Lake Chad. The river is an important part of the Hadejia and the Jama'are river system. The river basin occupies a total land area of about 16386.01 km² and is part of the inland drainage system of the Chad Basin (Olofin, 2005).

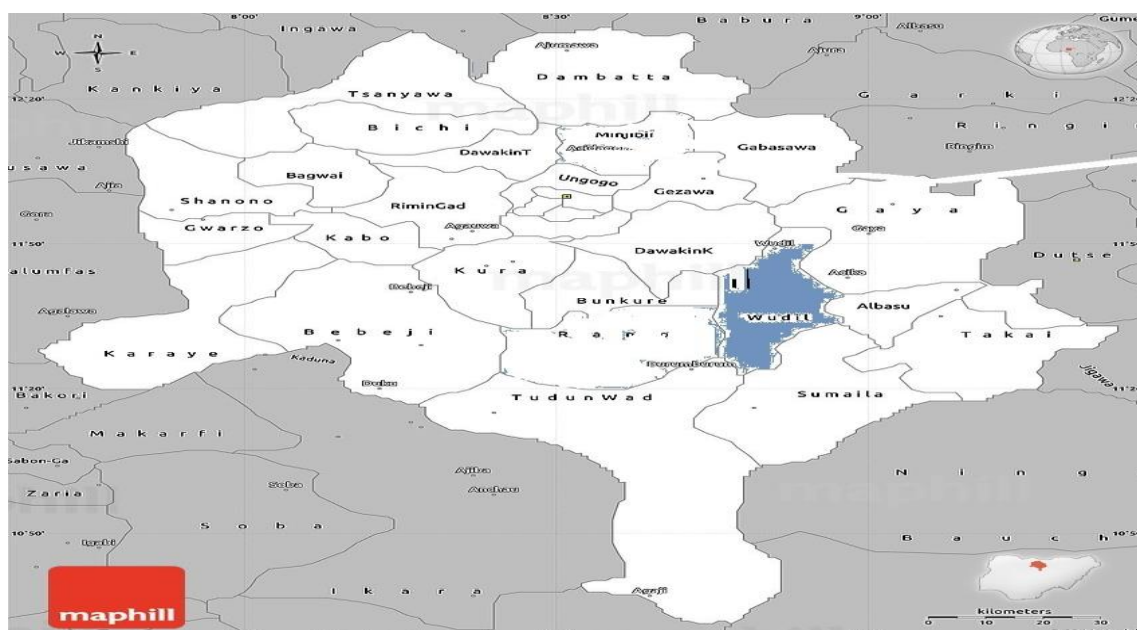


Figure 1: MAP OF KANO STATE HIGHLIGHTING WUDIL LGA

SOURCE: www.maphill.com/nigeria/kano/simple-maps/gray-map.

Collection and Identification of Fish Samples

165 pieces of *B. bajad* were collected immediately from fishermen at the landing site of river Wudil. Samples were collected in an ice-chest box to maintain the freshness of the fish. Various sizes of bayad ranging from small, medium to large were sorted out and used for this study. The samples were transported to the laboratory of Department of Fisheries and Wildlife, Kano University of Science and Technology, Wudil, Kano State, Nigeria.

Fish Measurement

Morphometric parameters were measured for each sample with the aid of measuring board and rule, weighing balance (top-loaded, Mettler balance model 2000 and Model HR 2385/A for small fish), dial callipers (Mitutoyo Corporation), pair of divider and thread of various length. These parameters were measured in centimetres (cm) and grams (g) and recorded on data collection sheets for each sample separately. Total length (TL), standard length (SL), and fork length (FL) of each sample were measured to the nearest centimetre (cm). The total weight (TW) and gutted weight (GW) were also measured to the nearest gram (g).

Length-Weight Relationship (LWR)

The length-weight relationship of male, female and combined sexes was determined from the formula:

$$W = aL^b \quad (\text{Le-Cren, 1951}); \text{ which was transformed to}$$

$\log_{10} W = \log_{10} a + b \log_{10} L$, where, log length was plotted against log weight to obtain a, b and r values.

Where:

W = body weight of fish (g)

L = total length of fish (cm)

a = intercept

b = growth exponent

r = regression coefficient

Condition Factor (K)

The condition factors (K) of male, female and combined sex were calculated using the formula:

$$K = \frac{100 \times W}{L^b} \quad (\text{Le-Cren, 1951})$$

Where:

K = Condition factor

L = Total length of fish (cm)

W = body weight of fish (g)

b = growth exponent

Sex determination

Each specimen was dissected ventrally with the aid of a small scissor inserted through the vent. Also, a semicircular cut was made laterally on the side of the specimen for better observation. The gonads, which are two parallel tubules located at the dorsal wall of the abdominal cavity were examined with a hand lens in the dissecting set kit.

Statistical Analysis

Morphometric data collected was presented using descriptive statistics, mean and standard deviation. The length-weight relationship was analysed with linear regression while the student's t-test was used to analyse the sex ratio.

RESULTS AND DISCUSSION

The mean total length, forked length, standard length and the total weight including their standard deviation, minimum and maximum range of *Bagrus bajad* from river Wudil were presented in table 1. The morphometric parameters showed that there were variations in the different types of length measured, total length = 21.08±3.36 cm, forked length=17.54±3.10 cm and standard length = 16.06±2.89 cm. The mean weight was 51.02±29.11 g. The length-weight relationship showed that growth exponent (b) was slightly higher in female than male and the value for male, female or combined all showed negative allometric growth. The R² values computed were 0.9858, 0.9813 and 0.9846 for male, female and combined respectively. They are all strong and reliable coefficient of determination. The condition factor varied between 0.93 and 1.16 and it was higher for male than female (Table 2).

Table 1. Morphometric parameters of *Bagrus bajad* from River Wudil, Kano

Parameters	N	Minimum	Maximum	Mean	Std. Deviation
Total length (cm)	165	15.70	30.00	21.08	3.36
Forked length (cm)	165	12.80	26.10	17.54	3.10
Standard length (cm)	165	11.50	24.50	16.06	2.89
Total weight (g)	165	19.50	133.57	51.02	29.11

Table 2: Length-Weight relationship of *Bagrus bajad* from River Wudil, Kano

Sex	a	b	Coefficient (R ²)	Condition factor
Male	0.525	1.0340	0.9858	1.16
Female	0.489	1.0611	0.9813	0.93
Combined	0.517	1.0398	0.9846	1.04

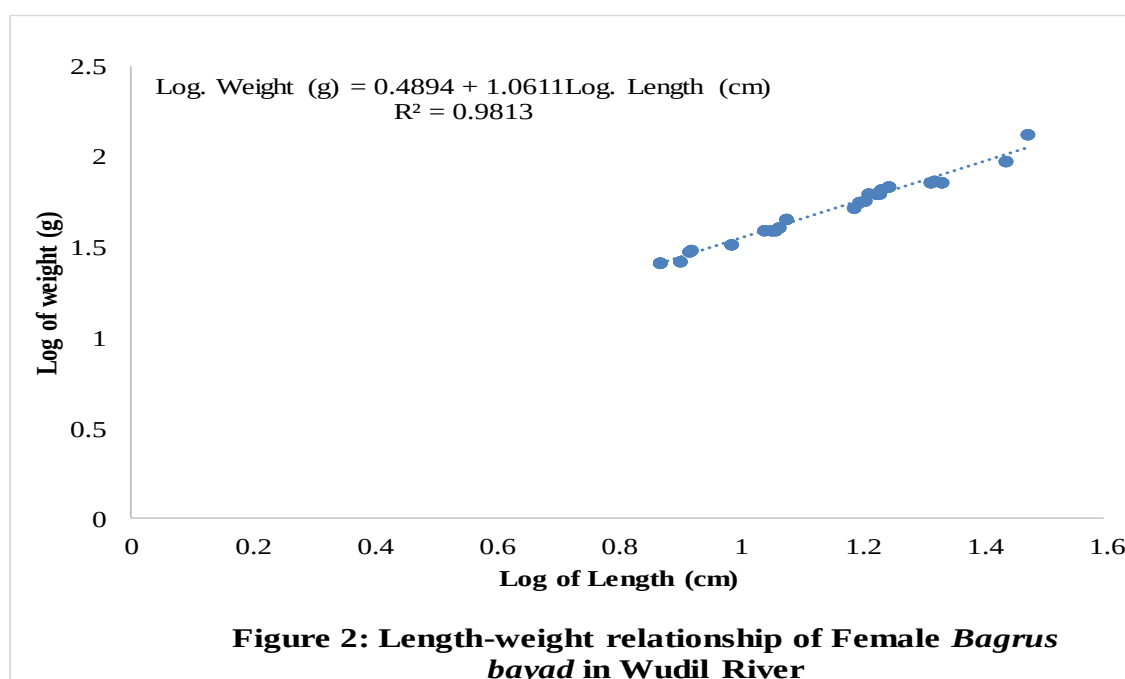
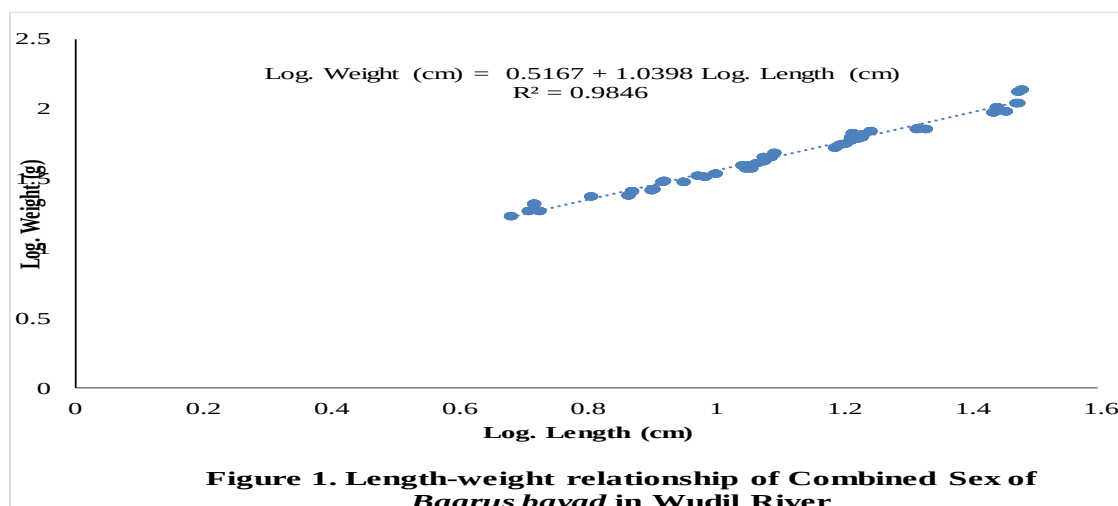
Table 3 has the results on the maturity stages of *B. bajad* samples from river Wudil. The sex ratio of the fish varies and not fixed within the different maturity stage. There are significant differences between the sex ratio of bayad that are immature, developing/maturing and the spent while the overall sex ratio and that of the matured didn't show significant differences.

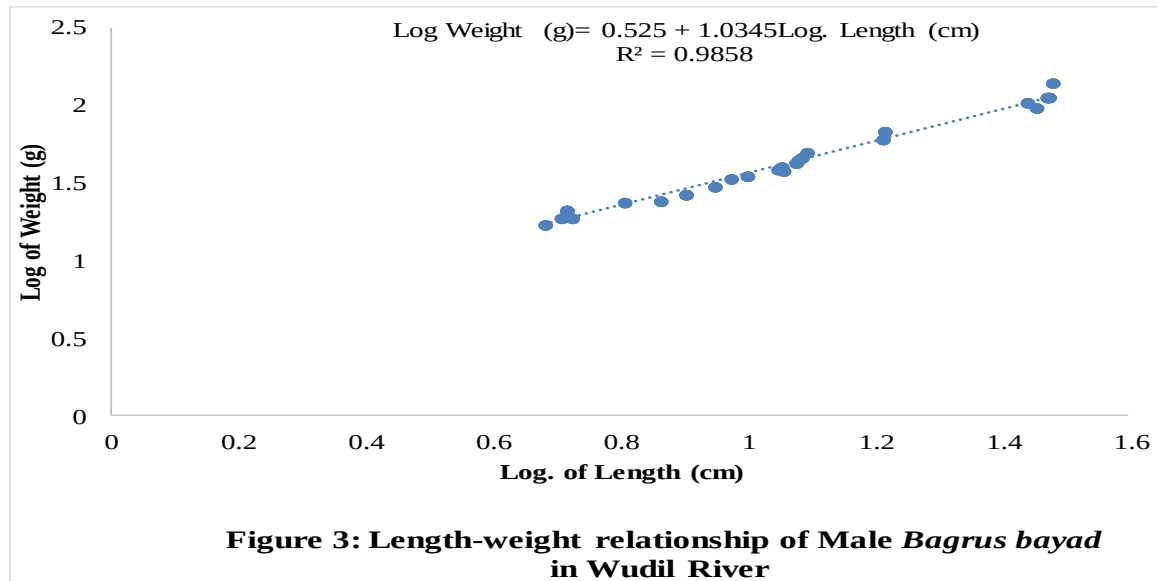
Table 3: Maturity stages and Sex ratio of *Bagrus bajad* from River Wudil, Kano

No. of male	No. of Female	Maturity stage	Sex ratio	t-test	Remark
33	19	Immature	1.7:1	2.06	significant
28	48	Developing / Maturing	1:1.7	6.58	significant

12	9	Matured	1.33:1	1.46	Insignificant
12	4	Spent	3:1	4.38	significant
85	80	Overall	1:1.0	1.31	Insignificant

The results of the regression for male, female and combined were shown in figure 1, 2 and 3, the predicted equations all had strong coefficients of determination and the regression lines are very close to perfect fits. This makes the equation more reliable for estimation of the weight of *Bagrus bajad* in river Wudil once the length is known.





The use of condition factor (K) and growth exponent (b) for comparison and assessing of a population or stock has been well established in fisheries management. It is being used in growth studies as well as modelling aquatic ecosystems (Dan-Kishiya *et al.*, 2018). *B. bajad* obtained from river Wudil for this study were all of negative allometric growth, with b values of less than 3. This indicates that the rate of increase in length is higher than that of the increase in weight (Jenyo-Oni *et al.*, 2014). The result is similar to that of Imam *et al.* (2010) for various species from Wasai reservoir in Kano and Dan-Kishiya *et al.*, (2018), for *B. bajad*, from Zobe reservoir, Dutsin-Ma, Katsina State. The negative allometric growth observed in this study could be linked to the nature of the species, a more slender fish that only gets plumpy as the size increases. The mean weight of 51.02 ± 29.11 g showed that the fish are still growing and the b values may improve as the fish gets bigger. The maximum weight of fish (133.57 g) observed in this study is similar to 140 g for *Clarias gariepinus* reported by Imam *et al.* (2010). The two species are very close in form and probably the reason why they both have b value of less than 3. Kolawole-Daniels *et al.* (2018) also reported negative allometric growth for grey mullet from Lagos Lagoon either for males, females or combined. According to Adeyemi *et al.* (2009), condition factor serves as an indicator of physiological states of the in relation to its welfare. K value of 1 and above is said to indicate a good physiological state. In this study the K value was more than one for males and combined sex but slightly less than 1 for females. All the bayad can be said to be in good physiological state (Jenyo-Oni *et al.*, 2014). Dan-Kishiya *et al.* (2018) also reported K value of greater than one for male, female and the combined sex for *B. bajad* from Zobe reservoir, Katsina State. It suffices to say the environment was good and favourable to the growth of bayad in river Wudil. Tejerina-Garo *et al.* (2005) also mentioned that the biological condition of fish is influenced by environmental factors. The significantly high R² values of 0.9858, 0.9813 and 0.9846 for male, female and combined respectively implies a very strong correlation between the length and weight growth. The distribution of *B. bajad* according to the sizes showed differences in sex ratio, the fish also showed that the majority of the fish are not yet matured. It is an indicator of a healthy stock, where the fish can gradually grow to mature size and reproduce to increase the population of *B. bajad* in river Wudil. However, there may be needs to monitor the gears being used to ensure fish that are supposed to grow to reproduce and increase the population are not caught before attaining maturity.

CONCLUSION

Length-weight relationship and condition factor (k) are important parameters that provide information on the well-being of fish species in an aquatic environment. *B. bajad* in river Wudil have negative allometric growth irrespective of sex, however, they all have good condition factor, which indicates a good

physiological state. The distribution of the ages of fish caught is also an indication of a promising water body with more fish that are yet to be matured and can be available with time to reproduce and increase the population of the fish in the water body. However, proper management has to be put in place to ensure the sustainability of the stock

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STOMACH CONTENTS AND INDEX OF FOOD SIGNIFICANCE OF *AUCHENOGLANIS BISCUTATUS* IN KIRI RESERVOIR, SHELENG, ADAMAWA STATE, NIGERIA

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ABSTRACT

Auchenoglanis species mainly feed on insect, aquatic larvae and small mollusks. These feeding habits enable them to stand a relatively wide range of ecological conditions. The study was conducted to investigate the stomach content and index of food significance of *Auchenoglanis biscutatus* in Kiri reservoir, Shelleng, Adamawa state, Nigeria for a period of six months (May to October, 2017). A total of 77 fish was collected at landing site, caught by gill nets of various mesh sizes. Each specimen was dissected using a pair of scissors to remove the gut and stomach of each fish and graded according to fullness. The graded stomach of each specimen was dissected length wise and emptied into a petri-dish for examination and identification. 56 (72.73%) had contents with various degree of fullness, while 15 (19.48%) specimens had empty stomachs. The stomach contents were analyzed using frequency of occurrence, Relative Frequency and the Points method. The food items in the stomach covered a wide variety, ranging from various types of Algae to insect parts. The major food items in terms of frequency of occurrence were *spirogyra* with 63.15% while insect parts had the lowest frequency of occurrence of 14.03%. The Index of Food Significance (IFS) of *A. biscutatus* showed that filamentous algae and colonial algae are secondary diet of the species, while its incidental diet include green algae, Cyanobacteria and Diatom, with IFS of <0.1 This report could help as data base needed to create a food web in Kiri reservoir, and eventually a trophic model in fisheries management.

Key word: stomach content, index of food significance, *Auchenoglanis biscutatus*, Kiri Reservoir.

Introduction

Auchenoglanis from the family Bagridae, is a genus of Claroteid catfishes native to Africa, is a primitive member of the subfamily Auchenoglanidinae and represents a stem group (Otero *et al.*, 2007). *Auchenoglanis* species mainly feed on insect, aquatic larvae and eventually small mollusks, alevin and swimming insects. These feeding habits enable them to stand a relatively wide range of ecological conditions (Otero *et al.*, 2007). They live in shallow regions near the shore in Northeast Africa, they are common in running water, lakes and submerged vegetation, the largest specimen recorded in Lake Nasser was 48 cm long (Azeroual *et al.*, 2010). Abdel-Aziz and Gharib (2007) reported that analysis of the stomach content of fish could provide information on better understanding of the trophic dynamics in the aquatic ecosystems by identifying their food composition and feeding habits as well as the stability and structure of its food web which is essential for sound fisheries management. Very little is known about the food and feeding habits of bagrids in the wild and *Auchenoglanis biscutatus* in particular in Nigeria Rivers. The present study is designed to generate baseline information on the feeding habits and index of food significance of *A. biscutatus* in Kiri reservoir. The information would be useful for food web studies and trophic status in the reservoir.

Materials and Methods

The study area was Kiri reservoir in Shelleng Local Government Area of Adamawa State, Nigeria. It is located within; Longitude 9° 40' 47" N 12° 00' 51" E. The reservoir was built by damming the Gongola River to provide irrigation to Savannah Sugar company (SSC) a large scale sugarcane plantation and processing company set up as a joint venture between the Nigerian Federal Government and the Commonwealth Development Corporation (CDC), London. The reservoir is 11.2km long, 20m high zoned embankment, with an internal clay blanket. The reservoir was completed in 1982 (ICE, 1990). The reservoir has a capacity

of 615m³ (Enplan, 2004). Fish specimens were procured from artisanal fishers and middlemen at their landing site for the study. Sampling of landed catches was done twice in a month for a period of six months from May to October, 2017 (Figure 1)

Sampling of Fish Species:

The fishers used a wide range of fishing gear such as hook and line, long line, cast nets, gill nets and traps. On the landing site, fish specimen were randomly sorted and identified using keys and descriptions by Olaosebikan and Raji, (1998) and Idodo-Umeh, (2003). Both male and female species were bought and conveyed immediately to the laboratory in plastic containers with ice-block for laboratory analysis on the same day as they were bought. A total of 77 species were sampled for this study. In the laboratory, the Total Length (cm) of each fish was taken from the tip of the mouth to the extended tip of the caudal fin using a measuring ruler to the nearest 0.1 cm. Standard Length (cm) for

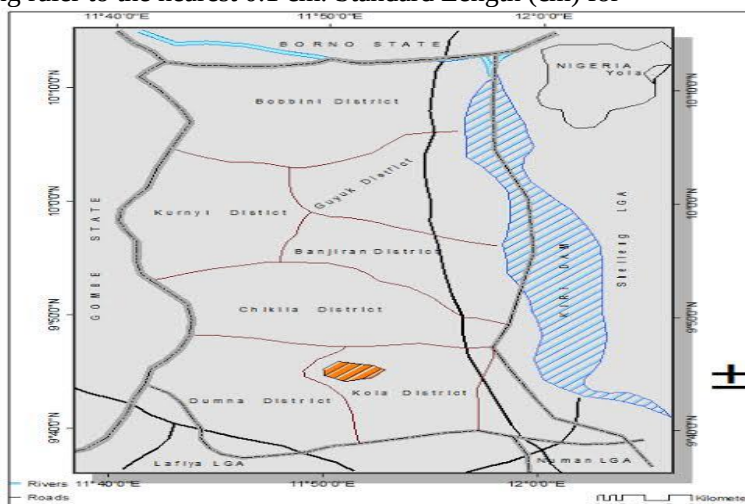


Figure 1: Map of Kiri Reservoir, Shelleng Local Government in Adamawa state (Enplan, 2004)

each fish was taken as measurement from the tip of the mouth to the caudal peduncle to the nearest 0.1 cm. The total body weight in grams was measured for each fish species to the nearest 0.01 g using a top loading Mettler balance. Each specimen was dissected using a pair of scissors to remove the gut, the entire stomach of the fishes were removed and graded according to fullness. The graded stomach of each specimen was dissected length wise and emptied into a petri-dish for examination and identification. Each stomach content was dispersed with small amount of distil water, sub-samples was taken from the stock and observed under a binocular dissecting microscope.

Stomach Content Analysis

The dissected stomach of each specimen and its degree of fullness was estimated by an arbitrary 0 - 20 point scale: thus 0, 2.5, 5, 10, 15 and 20 points was allotted to empty, trace, quarter-full, half-full, three quarter-full and fully distended stomachs respectively. Stomach contents sorted into categories and analyzed using Relative Frequency (RF) and point's method as described by Hyslop, (1980) and used by Chipps *et al.* (2002). In the RF, the frequency of a particular food item in all stomachs was expressed as a percentage of the frequencies of all food items. For the point's scheme, each stomach was allotted 20 points regardless of the fish size and these was shared amongst the various contents, taking account of their relative proportion by volume. The points gained by each food item in all stomachs examined was computed and expressed as a percentage of the total points of all food items. The point scheme gave an indication of bulk contribution of each food category to the diet composition. % RF and % PP (Percentage of total Points) was then used to determine the Index of Food Significance IFS as follows:

Relative Frequency= $f/n \times 100\%$. Where, f = frequency of individual food item, n = frequency of all food items

$$IFS = \frac{\%RF \times \%PP}{\sum (\%RF \times \%PP)} \times 100$$

Food with $IFS \geq 3\%$ will be regarded as primary, ≥ 0.1 to $<3\%$ as secondary, whereas food with $<0.1\%$ will be regarded as incidental. (Odo *et al.*, 2012)

RESULTS AND DISCUSSION

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A total of 77 *A. biscutatus* specimens were examined for their stomach contents, out of which 41 were Females, and 36 Males. The stomach content showed that 56 had contents with various degree of fullness, while 21 specimens had empty stomachs. Males had 14 specimens (Table 1)

The stomach contents of *A. biscutatus* was identified and grouped into their various categories. Using the Frequency of Occurrence method it showed that *Spirogyra* occurred more in the diet of *A. biscutatus* with a frequency of 63.15%, while the least was Rotaria with 12.69%. The Relative Frequency of the stomach contents showed that *spirogyra* and *volvox* has the highest with 13.23% and 12.73% respectively, insect parts had the least RF with only 0.85%. The Index Food Significance (IFS) of *A. biscutatus* shows that Filamentous Algae, Colonial Algae and Protozoa are the secondary diet of the species, while its incidental diet include Green Algae, Cyanobacteria, Protozoa and Diatom, with IFS of <0.1 (Table 2)

The condition factor (K) for *A. biscutatus* male has a range from 0.44-2.24 (mean value of $K=0.73\pm0.39$) females and combined has a range of 0.43-2.64 (mean value of $K=0.78\pm0.49$) and 0.39-2.64 (mean value of $K=0.75\pm0.44$) respectively (Table 3)

Table 1. Degree of Stomach Fullness of *Auchenoglanis biscutatus*

Sex	Full	Three-quarter	Half-full	One-quarter	Empty	Total
Male	6	2	8	14	6	36
Female	2	9	7	8	15	41
Total	8	11	15	22	21	77

Table 2. Index Food Significance of *Auchenoglanis biscutatus*

Food Items	Freq Occ(%)	PP (%)	RF (%)	$IFS = \frac{\%RFX\%PP}{\sum(\%RFX\%PP)} \times 100$
Green Algae				
<i>Clamydomonas</i>	29.82	4.43	4.72	0.25
<i>Closterium</i> spp	29.82	3.73	3.77	0.17
<i>Pediastrum</i>	22.80	2.09	1.98	0.04
Filamentous Algae				
<i>Spirogyra</i>	63.15	13.34	13.23	1.94
<i>Cladophora</i>	56.14	8.69	11.69	1.21
<i>Ulothrix</i>	52.63	10.06	10.09	1.11
<i>Pithopora</i>	56.14	9.17	8.36	1.12
Colonial green algae				
<i>Volvox</i>	54.38	11.30	12.73	1.86
Cyanobacteria				
<i>Lyngbya</i>	26.31	3.57	3.49	0.12
<i>Spirulina</i>	40.35	4.28	2.15	0.18
<i>Oscillatoria</i>	31.57	3.82	3.49	0.13
Diatom				
<i>Synedra</i>	28.07	3.44	3.11	0.11
Protozoa				
<i>Euglena</i> spp	23.54	2.43	2.67	0.32
<i>Paramecium</i>	15.78	3.32	2.68	1.33
Rotifers				
<i>Rotaria</i>	12.69	1.97	1.75	0.11
Copepoda				
<i>Copepod</i> spp	19.98	3.21	4.46	0.98
Other				
Sand grains	36.84	7.77	6.67	1.20
Scale	19.29	2.24	1.88	0.42

Insect parts	14.03	1.14	0.85	0.01
Total		100.00	100.00	

Table 3. Condition Factor of all the Fish Species

Sex	Number Examined	Range Value	Mean±SD
Male	36	0.44-2.24	0.37±0.39
Female	41	0.43-2.64	0.78±0.49
Combine	77	0.39-2.64	0.75±0.44

The analyses of stomach with various degree of fullness from the present studies showed a slight difference from what Ikongbeh *et al.* (2014) reported after examining 97 *A. biscutatus* from Lake Akata, they reported 62(63.9%) contained food with various degree of fullness, while 35(36.1%) had empty stomach and a sharp contrast from Meye and Ikomi, (2010), who examined a total of 521 species and recorded 472 (90.6%) had food in them with various degree of fullness, while the remaining 49 (9.4%) were empty. The differences could be tied to the time of the catch, since the catches were made in the early hours of the day when most of their stomach contents must have been digested. The frequency of occurrence of the food items in the stomach showed a sharp contrast with the report of Meye and Ikomi, (2010), who reported that *Ephemeropteran* nymphs were the most frequently occurring food item amounting to 87.9% which was followed by fine sand (70%), detritus (67%), green filamentous algae (58.9%) and nematode worms (53%). All other food items occurred in the range of 9-49%. Fishes have been known to be opportunistic feeders, making use with what is most available. The IFS reports is also in contrast with Ikongbeh *et al.* (2014), reported that main diet of *A. occidentalis* from Lake Akata to be insect with total point of 52.3% and a frequency of occurrence of 42.3%. Algae were of secondary importance with a total point of 22.3% and a frequency of occurrence of 36.1%. The other food items collectively formed less than (50%) of the total food items. These food items include insect larvae (16.6%), fish scale (5.41%) and unidentified food (4.3%). Offem *et al.* (2009) revealed that the major diet of *A. occidentalis* to be detritus (36%), fish fry (27%) and insects (18%). The result of the present study was also different when compared with the report of Chukwuemeka *et al.* (2015), who used the frequency of occurrence and dominance method to analyse the food in the gut of *A. occidentalis* from Tagwai Lake, Minna, the percentage of insects was (31.75%), fish (12.70%), protozoa (1.59%) and soil (12.70%). This could be due to the reason that the present studies was done when the lake experience high inflow of water and consequently high introduction of materials. The combined K value of *A. biscutatus* is lower to the report of Egbal *et al.* (2011) who recorded a condition factor of *A. occidentalis* in Kashm El-girba Reservoir as 1.905 ± 0.501 and 1.7739 ± 0.604 in Atbara River which is recommended as suitable for matured fresh water fish by Bagenal and Tesch (1978).

CONCLUSION

This study revealed that stomach content and index of food significance of *A. biscutatus* in Kiri Reservoir, has food composed mainly of plant origin; this could provide the data needed to create a food web in Kiri reservoir, and eventually a trophic model that can be used in fisheries management.

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SOME MORPHOMETRIC RELATIONSHIPS OF NILE TILAPIA, *OREOCHROMIS NILOTICUS* INHABITING GUZU-GUZU RESERVOIR, KABO LOCAL GOVERNMENT AREA OF KANO STATE, NIGERIA

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Abstract

The Nile tilapia, Oreochromis niloticus, is an African freshwater cichlid and one of the world's most important food fishes which plays a major part in fisheries and aquaculture. Information on fish morphometrics in Kano reservoirs are very scarce. Therefore, the present study focused on the morphometric relationships between different body measurements and total length of O. niloticus. The study has been carried out in Guzu-Guzu Reservoir in Kano State. The relationships between total length and various morphometric characteristics of the fish showed a linear and highly positive correlation with all coefficients of determination (R^2) values being > 0.80 . This information is very useful in identification of O. niloticus from Guzu-Guzu Reservoir and may also facilitate the determination of the locality from where the specimens of the same species came from.

Keywords: *Oreochromis niloticus*, morphometric relationships, Guzu-Guzu Reservoir, Kano State

Introduction

Morphometric study of fish is part of the vigorous tools for measuring discreteness of the same species (Naeem and Salam, 2005). Morphometric characters are among the most commonly used for differentiation of species populations (Felix *et al.*, 2021). Morphometric characterization of fish is not only essential to the understanding of the classification of fish but also, the health of the species involved; the shape and structures are unique to the species and the variations in its features are related to the habit and habitat among the fish species (Blackwell *et al.*, 2000). Information on fish morphometry is very useful for the development of

management strategies that will help in conserving the various fish species. This information and have been widely used in fish identification (Turan *et al.*, 2005; Saini *et al.*, 2008; Azadi *et al.*, 2013; Felix *et al.*, 2021).

Oreochromis niloticus (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; Keyombe *et al.*, 2017; Felix *et al.*, 2021). This study was carried out with the aim of determining the relationships between different morphometric characteristics and total length of *O. niloticus* in the selected Reservoir.

Materials and Methods

Study area: The study was carried out in Guzu-Guzu Reservoir, which is located in the Sudan savannah zone of Northern Nigeria on the latitude 11°58.25'N and Longitude 8°07.53'E (Figure 1). It is approximately 48 Km away from Kano in Kanye town, Kobo Local Government Area of Kano state, and about 13.25 Km from Kobo town.

Sample Collection: Fish samples were collected from fishermen catches at the landing site for a period of four months (September to December, 2019). A total of one hundred and sixty five (165) fish samples were collected and were transferred into an ice box packed with ice and immediately transported to the Fish Biology laboratory of the Department of Fisheries and Aquaculture, Bayero University, Kano for further measurements and analyses.

Laboratory studies: In the laboratory, a total of fifteen (15) selected morphometric characteristics were measured for each fish (Figure 2). The morphometric characters and their descriptions are shown in Table 1. The measurements were taken on the left side of the body of each fish facing the left hand side in accordance with Teugels (1984). Total length (TL) and standard length (SL) were measured in centimeter using fish measuring board. The remaining characters were measured also in centimeter using a digital vernier caliper.

Data analysis: The relationships between TL and the fourteen various morphometric characters (SL, HL, EL, ED, SNL, POL, POD, HW, PDD, PVD, PAD, PPD, BDA and MG) were examined using regression analysis and the regression coefficients (R^2) estimated. The formula $y = a + bx$ was used to work out the various relationships (Elamin *et al.*, 2011; Pervaiz *et al.*, 2012), where x = independent variable and y = dependent variable. All statistical analyses were performed using Microsoft Excel, MINITAB version 17 and SPSS version 22 statistics software.

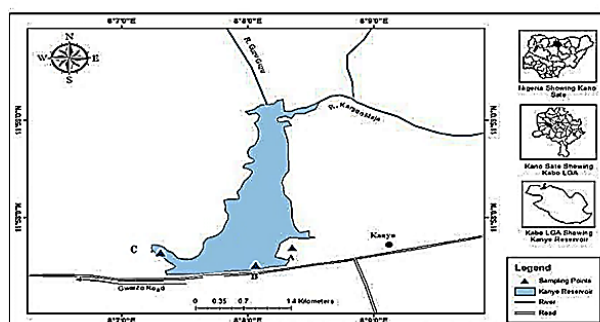


Fig 1: Map of the study area.

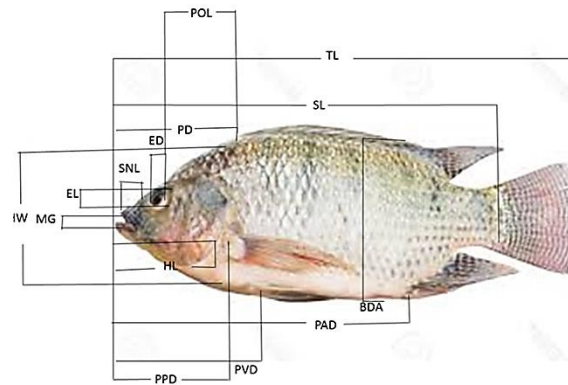


Figure 2: Morphometric characters of *O. niloticus* used in the study

Table 1: Descriptions of morphometric characteristics of *O. niloticus* used in the study.

Variables	Descriptions
Total Length (TL)	Length from the tip of the snout to the tip of the tail fin.
Standard Length (SL)	Length the tip of the fish snout to the base of the tail fin.
Head Length (HL)	Length from the tip of the snout of the posterior bony extremity of the operculum.
Eye Length (EL)	Length between upper and lower walls of the bony orbit.
Eye Diameter (ED)	Length between the anterior and posterior walls of the bony orbit.
Snout Length (SNL)	Length from the tip of the snout to the anterior margin of the orbit.
Post Orbital Length (POL)	Length from the tip of the snout to the anterior margin of the orbit.
Pre Orbital Distance (POD)	Length from front of snout to anterior of eye.
Head Width (HW)	Length between the margins at the widest area of the head between the opercula on either side.
Pre-Dorsal Distance (PDD)	Length from the tip of the snout to the structural base of the first dorsal fin ray.
Pre-Anal Distance (PAD)	Length between the tip of the snout and the insertion of the first ray of the anal fin.
Pre -Ventral Distance (PVD)	Length between the tip of the snout and the insertion of the first ray of the ventral fin.
Pre-Pectoral Distance (PPD)	Length between the tip of the snout and the insertion of the first ray of the pectoral fin.
Body Depth at Anus (BDA)	Vertical distance between the body margins through the posterior boarder of the anal opening.
Mouth Gape (MG)	Length between the angles of the mouth.

RESULTS AND DISCUSSION

Table 2 presents the summary of statistical analyses of the data of *O. niloticus* for the fifteen (15) selected morphometric characters. The TL was plotted against the various morphometric measurements so as to examine the extent of association between the different measurements. The relationships between TL and the various morphometric characteristics are summarized in Table 2. TL was also found to show a linear relationship against all the various morphometric characteristics. The regression coefficient (R^2) for TL compared against the various variables revealed high relationship. The scatter plots of different regression lines for the fish in the reservoir are contained in Figure 3.

Table 2: Summary of the statistical analyses of morphometric characters of *O. niloticus* from Guzu-guzu reservoir

MC	Range (cm)	Mean $\pm$ SD
TL	2.90 - 20.69	13.08 $\pm$ 4.82
SL	1.81 – 17.70	10.52 $\pm$ 4.30
HL	1.52 – 5.52	3.35 $\pm$ 98
EL	0.50 - 1.21	0.79 $\pm$ 0.20
ED	0.36 – 0.92	0.75 $\pm$ 0.14
SNL	0.30 – 1.21	0.80 $\pm$ 0.27
POL	0.90 – 2.92	1.70 $\pm$ 0.51
IOL	0.51 – 1.10	0.86 $\pm$ 0.17
HW	1.04 – 4.52	3.11 $\pm$ 0.91
PDD	1.41 – 5.11	3.26 $\pm$ 0.87
PAD	1.41 – 5.11	3.26 $\pm$ 0.87
PVD	1.41 – 5.74	7.73 $\pm$ 2.76
PPCD	1.52 – 4.68	3.38 $\pm$ 0.82
BDA	0.93 – 6.30	3.70 $\pm$ 1.27
MG	0.48 – 1.33	0.81 $\pm$ 0.24

Note: MC, Morphometric character; Range, minimum and maximum length

Table 2: Summary of regression analyses of the various morphometric characters of *O. niloticus* from Guzu-guzu reservoir

Relationship	Regression Equation	a-value	b-value	R ² -value
TL vs SL	y = 0.82TL + 0.47	0.82	0.47	0.96
TL vs HL	y = 0.17TL + 1.07	0.17	1.07	0.98
TL vs EL	y = 0.02TL + 0.48	0.02	0.48	0.91
TL vs ED	y = 0.04TL + 0.32	0.04	0.32	0.97
TL vs SNL	y = 0.03TL + 0.25	0.03	0.25	0.90
TL vs POL	y = 0.06TL + 0.79	0.06	0.79	0.93
TL vs IOL	y = 0.02TL + 0.47	0.02	0.47	0.84
TL vs HW	y = 0.20TL + 0.59	0.20	0.59	0.93
TL vs PDD	y = 0.18TL + 0.95	0.18	0.95	0.90
TL vs PAD	y = 0.69TL + 0.74	0.69	0.74	0.94
TL vs PVD	y = 0.17TL + 1.23	0.17	1.23	0.94
TL vs PPCD	y = 0.17TL + 1.10	0.17	1.10	0.91
TL vs BDA	y = 0.26TL + 0.35	0.26	0.35	0.94
TL vs MG	y = 0.02TL + 0.42	0.02	0.42	0.90

Note: a- intercept; b- slope; R²- coefficient of determination.

The significance of this study is to examine the relationship between total length and various morphometric characteristics of *O. niloticus* in Guzu-Guzu Reservoir and provide information on the species that will help in management and maintenance of biological equilibrium of the reservoir. *O. niloticus* showed a linear and highly positive correlation with all coefficients of determination (R²) values being > 0.80. This implies that other morphometric characters increase in lengths as total length increases Total length is the independent variables while other characters dependent on the total length (Elamin *et al.*, 2011; Arshad *et al.*, 2012; Azadi and Rahman, 2013; Felix *et al.*, 2021). The relationship between the various morphometric characteristics and total length reported in this study is the first record on *O. niloticus* in this water. Therefore, further studies are needed to confirm such findings.

CONCLUSION

The data produced in the present study provide the first fundamental information on morphometric relationship of *O. niloticus* from Guzu-Guzu Reservoir. Based on the present study, it was concluded that other morphometric characters increase in lengths as total length increases; this will help to know the state of the fish stock as well as for proper fishery management and sustainable exploitation of the stock.

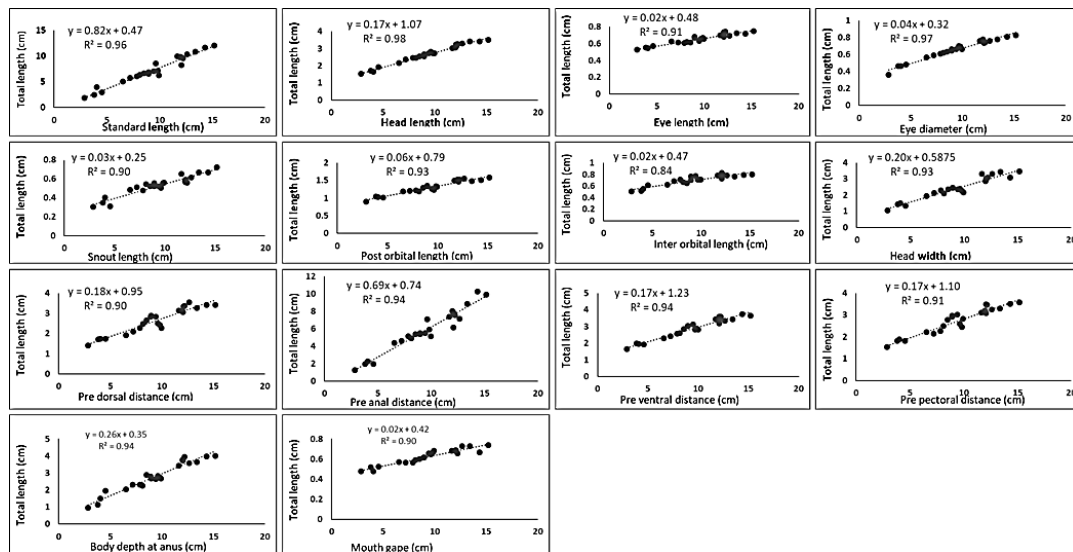


Figure 3: Relationships between total length and various morphometric characteristics of *O. niloticus*

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STOMACH CONTENT OF PARROT GRUNT (*POMADASYS PEROTETI*) FROM NEW CALABAR RIVER, PORT HARCOURT, NIGERIA

Chuckwu, K. O and Nwala, R.

ABSTRACT

The foods and feeding habits of *Pomadasys peroteti* in New Calabar River Port Harcourt, Rivers State, Nigeria was investigated in order to understand its food preferences and feeding habits via the stomach contents. The analyses of the stomach content were carried out by frequency of occurrence, number method, index of relative importance and index of stomach fullness. Crabs (82.2%) constituted the most important food component while teleost was the least (1.0%). Most of its prey teleost was intact in the stomach of *P. peroteti* examined. This is an indication that it swallows its prey whole. Feeding intensity was found to increase with fish size. Furthermore, the fish condition was better with higher stomach fullness. Hence this species would require high protein feed and elevated feed supply with increasing size to achieve better growth in captivity.

Keywords: Pomadasys, Food, Stomach Content, food habits, Prey.

Introduction

Food is an important factor regulating growth, abundance, feeding, and migratory movements of fish (Nyunja *et al.*, 2002). Feeding habit has become a part of their daily routine. This is because they depend on food in order to survive. Food and feeding habits have been known to vary from individual fish with respect to size, age, life history stage, kinds of food available, season, time of the day, as well as locality in which they are found Saliu, (2002). All fishes can consume a wide variety of food that are present in their habitats. The amount of food ingested per day and the times of day that feeding is performed depends on many factors. Daily and seasonal temperature fluctuations may affect food intake in most fishes. Some species feed mainly by sight and are active by day although peaks of feeding activity occur in the morning and evening. Other fishes that depend more on chemical sense can feed effectively in the absence of light or at night Hanjavanit and Sangpradub, (2009). The result of many studies on feeding of various fishes however show that small individuals consume more per day in relation to their body weight, than large individual. Freshwater fishes can be divided into four feeding types which are herbivorous, omnivorous, carnivorous and plankton feeders. Herbivorous fishes feed mainly on unicellular algae, filamentous algae and portions of higher aquatic plants along with some sand or mud. Plant material of the food is 75% or more of total gut content, hence considered herbivorous German and Horn, (2006). Omnivorous fishes, feed on unicellular and filamentous algae and aquatic plants, rotifers, insects, insect larvae, crustaceans, mud and sand. Carnivorous fishes feed on high percentage of animal materials such as crustacean mainly copepods, water bugs, beetles, dragonfly larvae, small fishes and tadpoles. This study aims to shed light on the food and feeding behavior of *P. peroteti*. This is expected to be helpful should the fish be considered for culture in captivity.

Materials and Methods

The study was carried out in New Calabar River Port Harcourt. The River lies at latitudes 04° 53' 19.020"N and longitude 006° 53' 53.086" E.

This study lasted for three months, from May to July 2019, twice a month samples were collected from artisanal fishers and middlemen at the New Calabar River Port Harcourt. Thereafter, samples were immediately fixed in 10% formalin

Stomach content was extracted by making a longitudinal cut along the ventral region, the stomach and its content was emptied into a Petri dish and examined under a microscope or hand lens.

Data obtained from examining the stomach was analyzed by Index of Relative Importance (IRI)

Thus, $IRI = (CN + CW) \%F$ Chukwu and Princewill (2019) where (CN) is number of prey, (CW) is weight and frequency of occurrence (F).

Feeding intensity was determined by Index of Fullness of Stomach or Intestinal Contents (IFS) IFS was calculated as $IFS = \frac{w}{W} \times 100$, where IF = Index of fullness

w = Dry weight of stomach or intestinal content, W = Fresh weight of fish. (Kenza *et al*, 2017)

Results and Discussion

A Total of 60 *P.peroteti* were collected from New Calabar River and were examined for food items consumed, (65%) contained food items. While (35%) had empty stomachs. Identified foods items included parts of crabs (82.2%), parts of shrimps (3.2%), teleost (1.0%) and unidentified items (13.5%).(Table 1). The occurrence of empty stomachs reduced with increase in size of fish, that is, as the fish grows and increase in size the higher the consumption of food and also the smaller the size the lower the food consumption of the species (Figure 1)

The index stomach fullness, (IFS) had its peak in June but had its lows in May and July. A similar trend was observed with condition factor (K) but with a reduced deviation, where the mean K value was 1.46 ± 0.04 and for IFS was 1.23 ± 0.45 respectively (Figure 2).

The fish fed more on parts of crabs, teleost was the least important food item found in the stomach and this result is similar to that of Kenza *et al.*, (2017). This further agrees with Akani and. Ekweozor, (1996) who reported that all sizes of *P.peroteti* did not include vegetable matter in their diet.

The decrease in empty stomachs with increasing size or age signifies a rise in feeding intensity with age or size. This could also result from better hunting abilities of the older or bigger fish. The low proportion of empty stomachs as observed in this study is similar to trends in predatory species as reported by Balogun (2000), Bachok *et al*, (2004) and Chukwu *et al.*, (2009). This finding did not align with that of Susana *et al* (2008) that reported decreasing stomach fullness with increasing size.

Table 1 Stomach content analysis of *Pomadasys peroteti* from New Calabar River

Gut content	Number	%N	Weight	%W	Frequency	%F	IRI	%IRI
Parts of crabs	105	78.4	18.2	41.2	21	53.8	6434.5	82.2
Parts of shrimps	10	7.5	11.2	25.3	3	7.7	252.6	3.2
Teleost	4	3.0	5.7	12.9	2	3.1	81.1	1.0
Unidentified item	15	11.2	9.1	20.6	13	33.3	1058.9	13.5

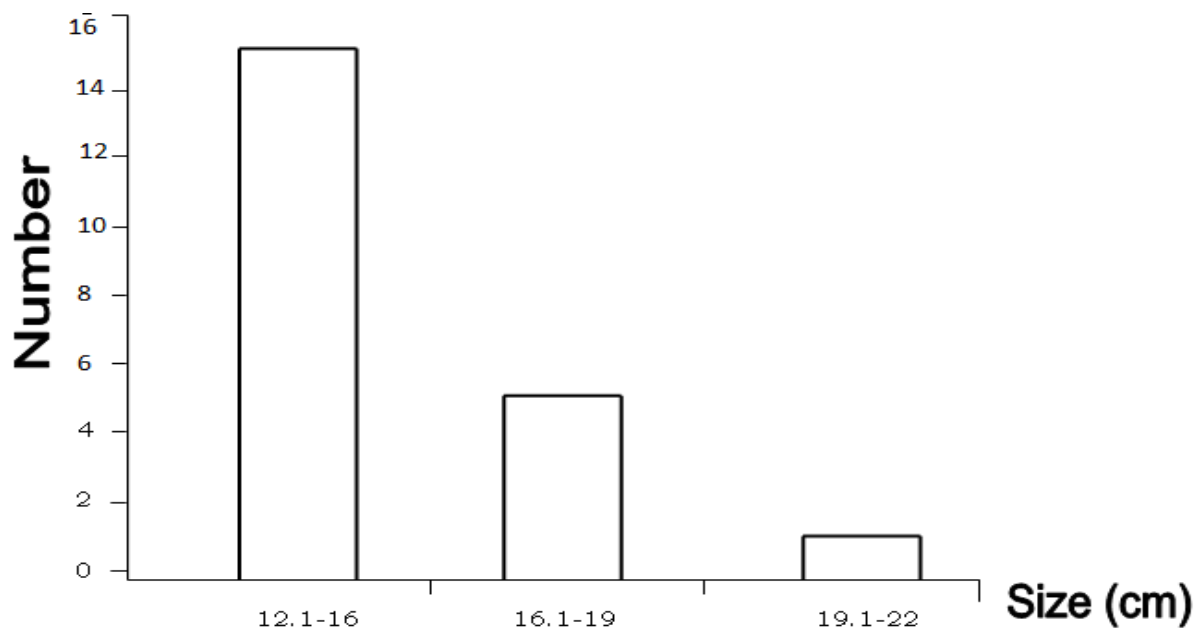


Figure 1: Percentage empty stomach of *P. peritote* with size class (cm)

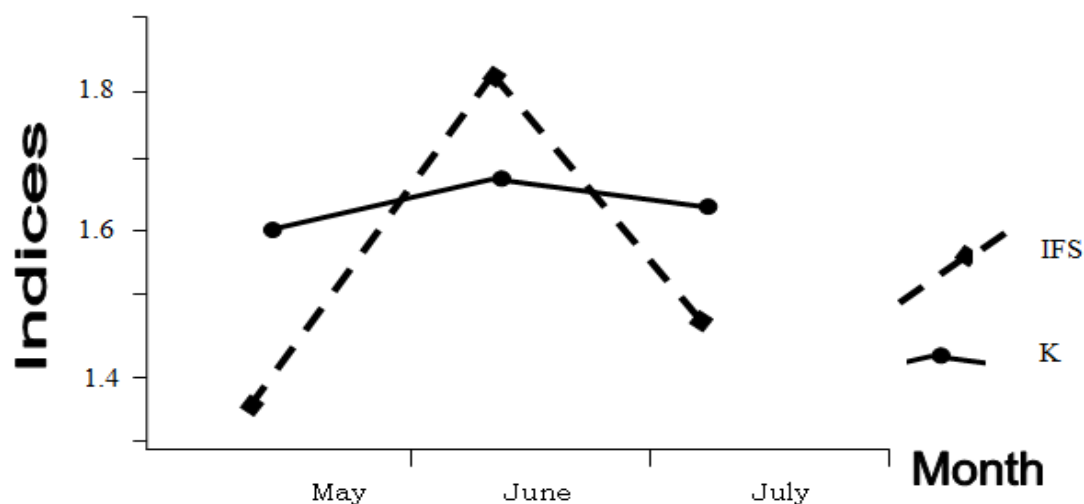


Figure 2: Index of stomach fullness and condition Factor (K) of *P. peroteti*.

The index of stomach fullness having a similar pattern with condition factor was a reflection of the fish well being which usually correlates positively with food availability and quality. This finding agrees with that of Kenza *et al* (2017) for *Sardina pilchardus*.

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EFFECTS OF ALCOHOL PRESERVATION ON THE MORPHOMETRIC CHARACTERISTICS OF *Clarias gariepinus* and *Oreochromis niloticus*

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ABSTRACT

The effect of alcohol (90% concentration) preservation on the morphometric characteristics of *Clarias gariepinus* and *Oreochromis niloticus* were investigated. The characters under investigation include total length, standard length, head length, body depth, eye diameter and total weight for the period of sixty-three (63) days. Twenty individuals of *C. gariepinus* and *O. niloticus* of similar recruits were obtained from Upper Benue river and transported to the laboratory for further analysis. Samples were first euthanized before taking the morphometric characteristics; after which the samples were preserved in separate bottles filled with 90% concentration alcohol for nine weeks (63days). Morphometric characteristics of the samples were later measured at the end of the 63 days to determine any possible changes. The results showed that the two studied fish species reacted to the 90% ethanol concentration preservation differently in which the *C. gariepinus* recorded higher percentage shrinkage compared to that *O. niloticus* which may be because of species differentiation, which determines the variation in tissue water content and the ratio of white to red muscle. The presence of scales may also be a factor, which may influence the surface ratio of the studied fish exposed to the preservative agent. The study revealed that 90% concentration of ethanol have a different effects but similar pattern on both *C. gariepinus* and *O. niloticus* species preserved for the period of sixty-three (63) days. However, more effects could have been observed if the preservation period is increased beyond 63 days, which may considerably affect subsequent and further biological analyses of the examined morphometric characters

KEYWORDS: alcohol preservation, morphometric characteristics, *Clarias gariepinus*, *Oreochromis niloticus*, shrinkage

INTRODUCTION

Preservation methods are generally used to maintain the integrity of biological specimens for long-term storage (Berbel-Filho et al., 2013). Although, these biological samples are generally preserved under varying conditions according to the purpose and further usage (Jawad et al., 2001; Jawad, (2003); Ghaly et al., 2010). For the identification of fish specimens, ichthyologists usually use formalin, alcohol, freezing and even chilling as a way to preserve morphological characteristics (Ghaly et al., 2010). However, several fields in fish biology like systematics, growth analyses and fishery stocks management use these morphological data extensively, and any interference that some preservation method may introduce, could directly influence the biological interpretation of the results. Haubrock et al., (2018) reported that storing fish samples in formalin and alcohol as a long-term measure may be reasonable, but the short-term storage of large quantities of such fish samples can be delicate and may not be the most efficient method of fish preservation. However, different short and long-term storage techniques have been shown to affect taxonomically important morphometric characteristics of fish, such as total length, head length, eye diameter, body depth and others (Al-Hassan and Shawafi, 2003). Inaccuracy or error in the morphometric measurement that do not reflect the real length of fish as a results of effects of preservation may considerably affect subsequent analyses (Porter et al., 2001)

Jawad et al., (2001), Jawad (2003) and Neave et al., (2006) have reported the effects of varying preservation methods on pigmentation and morphometric characteristics in different species of fish. These variations in morphology among different preserved species and samples were said to be as a result of several factors such as time elapsing until preservation, the applied preservation method, concentration of preservative, preservation duration and temperature, morphological variability among specimens, and species-specific factors (age, size, state, the osmoregulatory activity of the fish at the point of death) (Yeh and Hodson, 1975). Subsequently, the effects of storage and preservation methods between scale-less and scaled fish has also been reported to vary when considering the water content ratios of white and red muscles (Leslie and Moore, 1986). The present work examined the effect of 90% concentrations of alcohol on selected morphological characteristics of a scale-less fish, *Clarias gariepinus* and scaled fish, *Oreochromis niloticus*

Materials and Methods

Collection of samples: Twenty (20) individuals of *C. gariepinus* and twenty (20) individual of *O. niloticus* of possible similar recruits were obtain from the Upper Benue River, Yola. The *C. gariepinus* ranges between 11.56cm-12.65cm and 12.83g-13.45g in total length and total weight respectively while the *O. niloticus* ranges between 11.95cm-12.25cm and 37.76g-38.27g in total length and total weight respectively.

Experimental Set-up: Each of the twenty individuals of *C. gariepinus* and the twenty individuals *O. niloticus* were introduced into individual bottle, filled with 90% concentration of alcohol after first been euthanized. Each of the samples were preserved and stored in a single glass bottle and labelled. Measurement of the morphometric characteristics was done on the fresh samples prior to preservation and after nine weeks (63 days) of preservation.

Morphometric Measurement: Morphometric characters like body weight (BW), total length (TL), standard length (SL), body depth (BD), head length (HL) and eye diameter (ED) were taken. The body weight was measured by electronic weighing balance to the nearest 0.01g, while the total length, standard length, body depth, head length and eye diameter were measured using digital venier calliper)

Data Analysis: The data generated were analyzed using Statistical Package for Social Sciences (SPSS 22.0). A one way analysis of variance (ANOVA) was used to determine the significant differences in measured variables and Tukey's multiple comparison test was applied to identify differences between the means ($P=0.05$). The percentage shrinkage was also calculated to determine the decrease in the measured morphometrics characters in the fresh samples compared to the preserved samples.

$$\text{Percentage Shrinkage \%} = \frac{\text{fresh sample} - \text{preserved sample}}{\text{Fresh sample}} \times 100$$

RESULTS AND DISCUSSION

The effects of alcohol preservation on *C. gariepinus* and *O. niloticus* for the period of nine weeks (63 days) is presented in Table 1. The results showed varying degree of reduction in the morphometric characters of the studied samples. There was no significant differences ($p>0.05$) in all the morphometric characters in both *C. gariepinus* and *O. niloticus* before preservation and after preservation except in the mean total weight. *C. gariepinus* had higher reduction in mean total length, standard length, and head length while *O. niloticus* had higher reduction in the body depth, eye diameter and total weight. However, Higher percentage shrinkage was observed in all the characters in *C. gariepinus* compared to that *O. niloticus*

Table 1: Effects of 90% ethanol preservation on Morphometric characters of *Clarias gariepinus* and *Oreochromis niloticus* for the period of sixty-three days (nine weeks)

<i>Clarias gariepinus</i>				
Morphologicals character	Before preservation in alcohol (cm)	After preservation in alcohol	Shrinkage (cm)	Percentage shrinkage
Total length	11.76±1.24 ^a	11.06±1.23 ^a	0.70	5.95
Standard length	10.39±1.21	9.62±1.09 ^a	0.77	7.41
Head length	3.09±0.31 ^a	2.89±0.32 ^a	0.2	6.47
Body depth	1.64±0.16 ^a	1.55±0.14 ^a	0.09	5.48
Eye diameter	0.23±0.04 ^a	0.20±0.03 ^a	0.03	13.24
Total weight	12.91±3.34 ^a	10.91±2.77 ^b	2.12	16.42
<i>O. niloticus</i>				
Total length	12.09±1.47	11.81±1.43 ^a	0.28	2.39
Standard length	9.67±1.18 ^a	9.39±1.12 ^a	0.28	2.89
Head length	3.38±0.48 ^a	3.32±0.39 ^a	0.06	1.78
Body depth	4.10±0.33 ^a	3.94±0.31 ^a	0.16	3.90
Eye diameter	0.78±0.09 ^a	0.69±1.00 ^a	0.09	11.54
Total weight	38.04±9.92 ^a	33.87±8.17 ^b	4.17	10.96

The use of different preservatives have been reported to cause change in the body proportion of the fish. In this research, decrease in length in most of the characters measured was an evident of shrinkage of the morphometric characters and exit of interstitial fluid as reported by Hossaini, *et al.* (2016). The shrinkage observed over the preservation period is in accordance with the results of Jawad *et al.* (2001); Jawad (2003) and Hossaini, *et al.* (2016) who all revealed that different concentrations of alcohol causes various degrees of shrinkage in total length, standard length and head length. The higher percentage shrinkage observed in total weight, eye diameter and body depth in both species also corroborate with the work of Berbel *et al.* (2013) who also reported higher percentage shrinkage in body depth and eye diameter. However, the result is obtained from this study is different from the work of Scott *et al.*, (2016) who reported length gain in bluegill larvae preserved in 90% alcohol for the period of twenty-six (26) days while Jawad (2003) also reported no effect of alcohol preservations on the head length of *Alepes djeddaba* preserved at 70% concentration.

Changes in morphometric characters of preserved species has been reported to be influenced by various factors such as method of preservation, concentration and type of chemical preservation agents, length of preservation period, salinity and temperature of the preservative (Macdonald et al. 1997; Jawad, 2003; and Hossaini, *et al* 2016). The type of species, age, size and developmental state of the preserved fish are all factors that determine changes in morphometric characters of a preserved fish. The two studied fish species reacted to the 90% ethanol concentration preservation differently in which the *C. gareipinus* recorded higher percentage shrinkage compared to that *O. niloticus* may be as a result of species differentiation which determines the variation in tissue water content and the ratio of white to red muscle. The presence of scales may also be a factor, which may influence the surface ratio of the studied fish exposed to the preservative agent.

In conclusion the study revealed that 90% concentration of Ethanol have a different effects but similar pattern on both *C. gareipinus* and *O. niloticus* fish species preserved for the period of sixty-three (63) days. However, more effects could have been observed if the preservation period is increased beyond 63 days which may considerably affect subsequent and further biological analyses of the examined morphometric characters

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LENGTH-WEIGHT RELATIONSHIP AND CONDITION FACTOR OF *CLARIAS GARIEPINUS* (BURCHELL, 1822) FROM ZOBE RESERVOIR, KATSINA STATE, NIGERIA

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ABSTRACT

The study evaluated the length-weight relationship and condition factor of *Clarias gariepinus* in Zobe reservoir. A total of 90 fish were sampled for the period of 6 months and the length and weight were measured. Results showed that fish population consist of 47 males and 43 females. The length -weight regression analysis showed b-values of 2.80, 2.89 and 2.85, in males, females and combined sex respectively which indicated negative allometric growth. The significant linear relationships (r) of 0.97, 0.96 and 0.96 were recorded in both males, females and combined sex respectively. The condition factor (K) 1.04, 1.04 and 1.04 reported is the same for the male, female and in the combined sex. Condition factors “K” values recorded greater than 1 in the study showed that both the male and female *C. gariepinus* from Zobe Reservoir were in good and healthy condition. The condition factors of all fish species sampled fall within the range recommended as suitable for matured fresh water fish species in the tropics.

Keywords: Allometric growth, Condition factor, African catfish, Zobe reservoir.

Introduction

African mud catfish (*Clarias gariepinus*), is one of the most important fish species in aquaculture and commercial fisheries in Africa. It is widely distributed in water bodies across the continent. This species is found in most water bodies, ranging from swamps, temporary pools, streams, rivers and lakes. *Clarias gariepinus* (Burchell, 1822) has been found to be a very important freshwater fish in Nigeria and aquaculture productions due to its several valuable features such as its ability to tolerate a varying range of environmental conditions, fast growth rate, high fecundity rate, ease of artificial breeding and it commands good price (Sadauki *et al.*, 2022).

Stock assessment is a major and significant instrument required for producing inputs necessary in developing approaches and appropriate managements for the improvement and enhancement of the species in any water body (Gusau *et al.*, 2020). Effective management of this fish species, among other fishery resources, requires considerable knowledge of population parameters such as length-weight relationship (Dan-kishiya, 2013). According to Dan-kishiya *et al.* (2018), growth is an irretrievable increase in length and weight of living material and essential attribute of all breathing organisms. Growth and development can be measured at numerous stages of life or developmental levels of living things at the level of the organism. There are varieties of parameters which may be measured including length, surface area, volume and mass. Length-weight data is used to appraisal/estimate the wellbeing and welfare of the fish (Nababa *et al.*, 2021). Condition factor is an index to relate quantitatively the state of single fish within a given populace, individual fish from different inhabitants, and two(2) or more populace from different localities (Yusuf and Abdulkarim, 2015). The results can be used to forecast weight from length measurements made in yield assessment (Suleiman *et al.*, 2017). The condition factor (K) serves as an indicator of physiological state of the fish in relation to its welfare. It also provides information when comparing two populations living under different feeding densities and climatic conditions (Suleiman *et al.*, 2017).

MATERIALS AND METHODS

Study Area

Zobe reservoir, situated in Dutsin-Ma Local Government Area of Katsina State, is located between latitude 12°20'34.62"N and 12°23'27.48"N and between longitude 7°27'57.12"E and 7°34'47.68"E. Zobe reservoir was constructed on River Karaduwa and extends to about 7 km long and a surface of about 4,500ha. Zobe reservoir has only two tributaries; these include River Karaduwa and River Gada in which River Gada drains to River Karaduwa (Apollon *et al.*, 2016). Annual rainfall in the area varies from 600-700mm with mean annual temperature of about 25°C (Sadauki *et al.*, 2022).

Sample Collections

Samples of African mud catfish, *Clarias gariepinus*, were collected monthly from the study area for period of (6) months. Five (5) samples were collected from three sample locations (15) monthly with the assistance of local fishermen who used their drag nets and traps for fish capture. The fish samples were transported alive to the Biology laboratory, Federal University Dutsin-Ma, Katsina State, in a plastic container filled with water for identification. Fish samples were identified using the description of Olasebikan and Raji (1998). Morphometric measurements such as body weight, total length and standard length were taken following the method for morphometrical identification of *Clarias* species.

Determination of Length-Weight Measurement

The length – weight relationship of *Clarias gariepinus* was calculated using the formula described by Le-Cren (1951);

$$W = aL^b,$$

where W = Weight of fish (g), L = Length of fish (cm), a = constant and b = growth exponent.

The values of constants a and b was estimated after logarithmic transformation of $W = aL^b$ using least square linear regression to give: $\text{Log}W = \log a + b\text{Log}L$.

Determination of Condition Factor

The condition factor K was determined for each sampled fish using the conventional formula as described by Froese (2006). The ratio of the length to the weight of the fish was determined as:

$$\text{Condition Factor (K)} = \frac{W \times 100}{L^3},$$

where K = Condition factor, W = Weight in grams and L = Length in cm

Results and Discussion

The length-weight relationship and condition factor for both sexes and combined were determined. The growth exponents (b) were 2.80, 2.89, and 2.85 for males, females and combined sexes respectively (Figures 1 to 3). The 'r' value was greater than 0.90 for all the fish sampled obtained from Zobe reservoir (Table 1). There was strong correlation between the fish's length and weight as shown in Table 1, the K value obtained was 1.04 for male, 1.04 for female and 1.04 for combined sexes.

Table 1: Length-weight relationships and condition factor of *Clarias gariepinus* in Zobe reservoir, Dutsinma, Katsina State

	Mean condition factor (K)	$W = aL^b$	N	A	B	r
Male	1.04	$-1.77L^{2.80}$	47	-1.77	2.81	0.97
Female	1.04	$-1.85L^{2.89}$	43	-1.85	2.89	0.96
Combined	1.04	$-1.81L^{2.85}$	90	-1.81	2.85	0.96

N= number of samples, a = intercept/regression constant, b = the slope/regression coefficient, r = the correlation co-efficient, K = condition factor

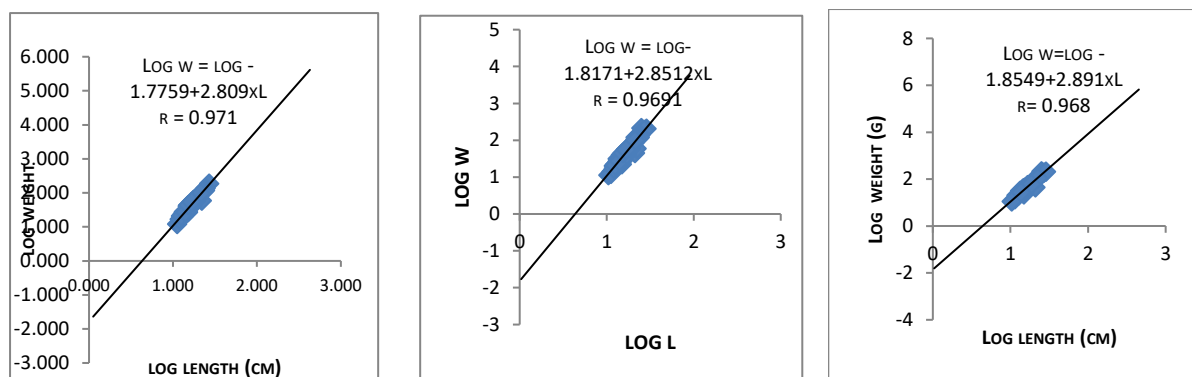


Figure 1 *C. gariepinus* male combined

Figure 2 *C. gariepinus* female

Figure 3 *C. gariepinus*

The results of length-weight relationship of the African catfish obtained from Zobe Reservoir revealed allometric pattern of growth. The b values for *Clarias gariepinus* obtained from Zobe reservoir were less than 3.0 indicating negative allometric growth; this implied that the weight of fish increases at a lesser rate than the cube of the body length. This agrees with the study of Kumolu-Johnson and Ndimele (2011) who reported similar growth for *Clarias gariepinus* in Ologe Lagoon, Lagos. Negative allometric growth pattern in freshwater fishes has been reported (Dan-kishiya *et al.*, 2018; Dan-kishiya, 2013). The coefficient of determination (r) for length-weight relationship for *Clarias gariepinus* male was 0.971, female was 0.968 and 0.969 for combined sexes. This is in agreement with previous findings (Lalèyè, 2006). All the fish species sampled in the different sampling sites in the present study had condition factors ≥ 1 , and the K value obtained was 1.04 male 1.04 female, 1.04 combined sexes and were within the standards recommended by Ujjania *et al.* (2012) who stated that condition factor greater or equal to one is good, indicating a good level of feeding, and proper environmental condition.

Conclusion

The outcome of the current research revealed that *C. gariepinus* in Zobe reservoir in Dutsin-ma Local Government Area of Katsina State, exhibited negative allometric growth pattern irrespective of their sex. However, the condition factor indicated that all the fish are of good status and living a favourable environment.

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PRELIMINARY SURVEY ON THE DIVERSITY AND ABUNDANCE OF FISH SPECIES IN SOUTHERN BASIN OF KAINJI LAKE, NIGER STATE, NIGERIA

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ABSTRACT

The study was carried out between the months of August, 2021 and October, 2021 at the southern basin of Kainji Lake. The fish caught by fishermen were assessed at the landing sites, identified and sorted to the species level using identification manual. The fish were counted, weight were taking using weighing balance to the nearest gram 0.0g and recorded on data record sheet. The highest fish diversity was recorded in the family Mormyridae followed by the families Claroteidae, and Cichlidae next to Alestidae, Cyprinidae, Mochokidae while the low diversity are the families Distichodontidae, Citharinidae, Schilbeidae, Bagridae, Polypteridae, Latidae, Tetraodontidae and Malapteruridae and *Citharinus citharus* is the most abundance species accounted (30.12%) follow by *Chrysichthys filamentous* which recorded (15.26%) while the least abundance species are *Polypterus senegalus* and *Malapterurus electricus* with (0.13%).

Key words: Abundant, Diversity, Specie.

Introduction

Diversity and abundance of fish species are known through a survey study using fishermen catch and experimental gill netting to source an information that will help in monitoring and management of inland water bodies (Ibrahim *et al.*, 2015).

Fishery management systems depend on regular stock assessments to determine stock status and to provide appropriate advice for management decision to achieve fishery and conservation objectives. Stock assessment involve provision of information on recruitment, mortality, migration, fishery monitoring, and resource surveys for estimating stock size and harvest rate relative to sustainable reference points. It compares the present and expected fish abundance at a particular period of time to determine the exploitation level of the stock whether the stock is overexploited or not (Edward, 2013). This study is aim to carry out a preliminary study on diversity and abundance of fish species in the Southern basin of Kainji Lake.

Materials and Method

Kainji Lake is located between the longitude, 4°21' and 4°45' East and latitude, 9°5' and 10°55' North. It was formed in 1968 covering a surface area of about 1243km² (480sq. m.) with a maximum depth of 12.1m (40ft) with a total volume of 15km³ (12,000,000 acre ft). The lake is located at the North Central in parts of Kebbi and Niger State. The study was carried out between the months of August, 2021 and October, 2021. The fish caught by fishermen were assessed at the landing sites as shown in plates 2 and 3. The fish were identified and sorted to the species level using identification manual (Olaosebeka, R. O and Aminu Raji 2021). The fish were counted, weight were taking using weighing balance to the nearest gram 0.0g and recorded on data record sheet.

Shannon-Wiener index diversity and Excel were used to analyze data.

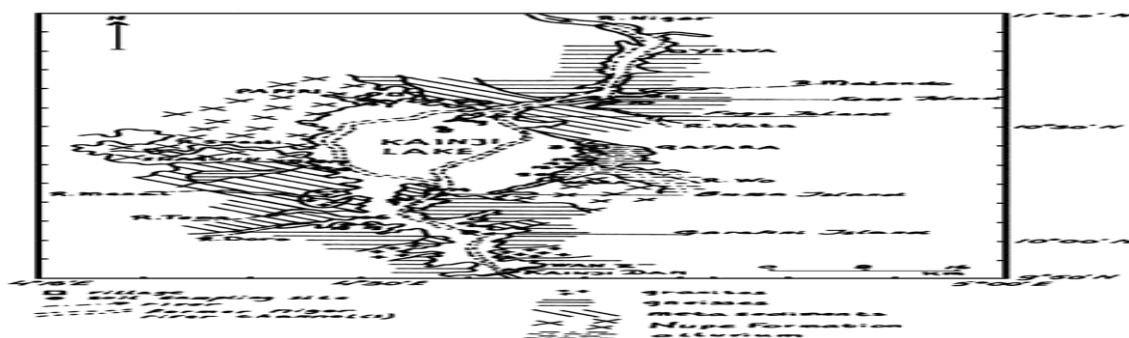


Plate 1: Map of Kainji Lake



Plate 2: fish caught by fisherman



Plate 3: fisherman landed with fish caught

Results and Discussion

The Shannon-Wiener diversity index of 14 families indicating a strong relationship with overall species richness, showed variation and range from 0.001 to 0.008 (table 1), the highest fish diversity was recorded in the family Mormyridae followed by the families Claroteidae, and Cichlidae next to Alestidae, Cyprinidae, Mochokidae while the low diversity are the families Distichodontidae, Citharinidae, Schilbeidae, Bagridae, Polypteridae, Latidae, Tetraodontidae and Malapteruridae. These low fish diversity of some families maybe due to the environmental factors such as competition, fishing activities, nature of the water body and activities going on the lake etc. These findings are contrary to the finding of Yem *et al.*, (2019), where *Bagrus bayard* has the highest fish diversity with (31.11%) and *parailia pellucid* has least diversity accounted (3.15%).

Table 2 indicate that *Citharinus citharus* is the most abundance species accounted (30.12%) followed by *Chrysichthys filamentous* which recorded (15.26%) while the least abundance species are *Polypterus senegalus* and *Malapterurus electricus* with (0.13%), these differences may be due to the period of the study. The present study is contrary to the finding of Ibrahim *et al.*, (2015), where *Mormyrus rume* has the highest abundance with (10.57%) and the lowest in abundance are *Mormyrus macrophthalmus*, *Chromidon tilapia guntheri*, *Heterotis niloticus*, *Malapterurus electricus*, *Synodontis membranaceus*, *Synodontis sorex*, and *Synodontis nigrita* recorded (0.25%).

Table 1 Fish Diversity, using Shannon-Wiener index, at the southern basin of Kainji Lake

Families	Total No. of species	Diversity index
Alestidae	2	0.002
Distichodontidae	1	0.001
Citharinidae	1	0.001
Cyprinidae	2	0.002
Schilbeidae	1	0.001
Claroteidae	3	0.005
Bagridae	1	0.001
Mochokidae	2	0.002
Polypteridae	1	0.001
Latidae	1	0.001

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Mormyridae	4	0.008
Cichlidae	3	0.005
Tetraodontidae	1	0.001
Malapteruridae	1	0.001

Table 2: Fish Abundance in southern basin of Kainji Lake

Family/Species	No.	% No.
Alestidae		
<i>Alestes baremoze</i>	22	1.47
<i>Hydrocynus forstalii</i>	27	1.81
Distichodontidae		
<i>Distichodus rostratus</i>	20	1.34
Citharinidae		
<i>Citharinus citharus</i>	450	30.12
Cyrpinidae		
<i>Labeo senegalensis</i>	21	1.41
<i>Labeo coubie</i>	66	4.42
Schilbeidae		
<i>Schilbe micropogon</i>	37	2.48
Claroteidae		
<i>Auchenoglanus occideitalis</i>	31	2.08
<i>Chrysichthys filamentous</i>	228	15.26
<i>Clarotes laticeps</i>	42	2.81
Bagridae		
<i>Bagrus bayad</i>	39	2.61
Mochokiade		
<i>Synodontis schall</i>	125	8.37
<i>Synodontis membranaceas</i>	53	3.55
Polypteridae		
<i>Polypterus senegalus</i>	2	0.13
Latidae		
<i>Lates niloticus</i>	35	2.34
Mormyridae		
<i>Marcusenius isidori</i>	19	1.29
<i>Mormyrus rume</i>	14	0.94
<i>Mormyrop tapinus</i>	11	0.74
<i>Petrocephalus bane</i>	4	0.27
Cichlidae		
<i>Tilapia zilli</i>	6	0.40
<i>Oreochromis niloticus</i>	93	6.22
<i>Sarotherodon galilaeus</i>	143	9.57
Tetraodontidae		
<i>Tetraodon lineatus</i>	3	0.20
Malapteruridae		
<i>Malapterurus electricus</i>	2	0.13
Total	1493	100

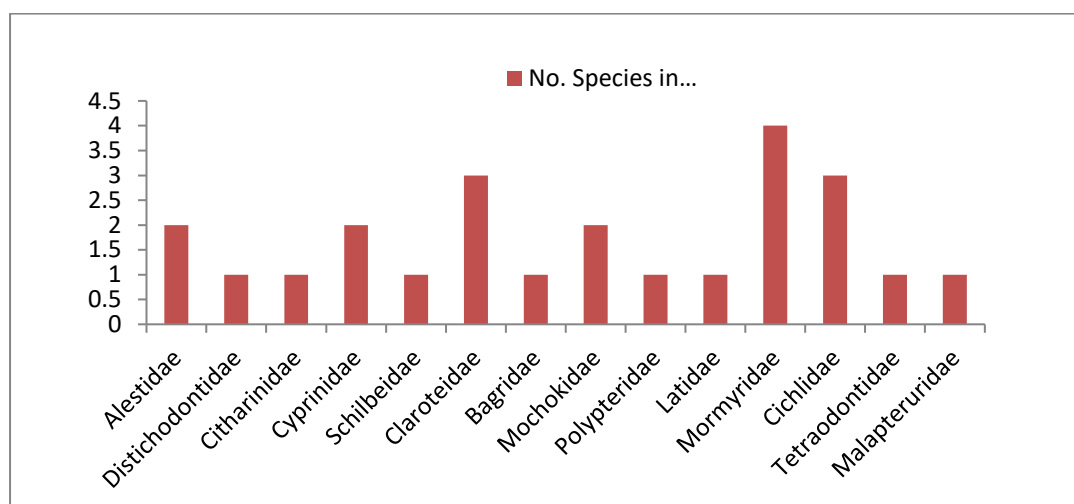


Figure 1: Diversity of species in family

Figure 1: Indicate that the family Mormyridae has the highest fish diversity while the families Distichodontidae, Citharinidae, Schilbeidae, Bagridae, Polypteridae, Latidae, Tetraodontidae and Malapteruridae has the lowest fish diversity.

Conclusion and Recommendation

Base on this study current fish diversity and abundant of the southern portion of Kainji Lake is gradually becoming low when compared with the previous studies. Agency concern needs to advice, control and monitor the fishing activities by the fishermen around lake.

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ABSTRACT

Rational management of fisheries resources requires an understanding of the composition and diversity of fishes in natural water bodies. While a lot of water bodies have been studied, there is still a good number of water bodies with limited information, Dutsin-Ma reservoir is an example of such a water body. This study was carried out to examine the ichthyofauna composition of the Dutsin-ma reservoir from April to May 2021. Fish caught from artisanal fisherfolks using monofilament gillnets and cast-nets were sampled twice a week for eight weeks. A total of 12 species, 7 genera and 3 families were encountered. The families Cichlidae (89.9%), Clariidae (5.7%) and Cyprinidae (4.4%) constituted the fishery resources. *Sarotherodon galilaeus* (34.6%), *Oreochromis niloticus* (29.8%) and *Coptodon zillii* (14.6%) were the major species of the family Cichlidae, while *Clarias gariepinus* (5.2%) was the major species from the Clariidae family and *Labeo senegalensis* (1.3%) was the major species of Cyprinidae family. The species diversity was similar for fisher B and C, and higher than that of fisher A. Evenness and Dominance values were similar among the catches from all the selected fisher folks. The reservoir showed a good potential source of fisheries resources and it may be important to put laws and regulations in place for proper management of the resources

Keywords: Clariidae; Cichlidae; Cyprinidae; Dutsin-Ma reservoir; Fish composition

Introduction

Nigeria is blessed with vast natural water resources, including coaster and inland water bodies. Over the years successive governments at different levels have also created a good number of man-made reservoirs by damming rivers (Dauda *et al.* 2017). This is done to make water available for domestic purposes, hydroelectric power generation, and farmland irrigation among others (UCSUSA, 2013). However, so many people have found a source of livelihood from these water bodies, either directly or indirectly. Among the direct jobs created by water bodies are fishing. Over 8.6 million people are directly employed in the fisheries sector, either in artisanal or industrial fishing. While another 19.6 million people are indirectly involved along the fisheries value chain (Worldfish, 2018). Therefore, these water bodies need to be rationally managed for the continuous exploitation of fish, in order to ensure the jobs of both fishermen and others along the value chain are kept. A fundamental need for rational management is to first understand the available fisheries resources, abundance and distribution (Adaka *et al.*, 2014). These have led so many researchers to study the fish composition of several water bodies in the country including Ikere-gorge dam, Oyo state (Ajagbe *et al.*, 2021), Challawa gorge dam, Kano State (Nazeef *et al.*, 2018), Lower Ogun river wetlands, Lagos State, (Hassan *et al.*, 2014) among others. Katsina State is located in Northwestern Nigeria and it has about 40 man-made reservoirs (Dauda *et al.*, 2015), including the Zobe and Dutsin-Ma reservoirs in the Dutsin-Ma Local government areas of the state (Dauda *et al.*, 2021). While Zobe reservoir, a major water body and one of the largest in the state has received a lot of attention in terms of water quality (Sadauki *et al.*, 2022), fish composition and abundance (Ahmad *et al.*, 2014) among other studies. Dutsin-Ma reservoir is a relatively small water body but there is a paucity of information on the fish composition of the reservoir, despite reports of fishing activities going on in the water body (Dauda *et al.*, 2021). It is therefore expedient to understand fish composition in the water body to propose appropriate management strategy to the government for policy formulation and the end users to ensure sustainable exploitation of the fisheries resources. Hence, this research was set out as a preliminary study to assess the ichthyofauna composition of the water body using the fishermen catch approach.

Material and methods

The study area

The research was carried out in the only landing site of Dutsin-Ma reservoir, Dutsin-ma, Katsina State. The reservoir is located at latitude 12°28' 0.7" N and longitude 7°29'56"E with a perimeter of 5.05 km and covered an area of 1.10 square kilometres, Figure 1 (Dauda *et al.*, 2021). The region experiences four months of the rainy season, June – September with rainfall annually ranging between 1500 -1800 mm (Dasuki *et al.*, 2014). Dutsin-Ma reservoir was constructed in 1974 for the primary purpose of domestic water supply and it receives water through three main sources only during the rainy season, these sources are namely Western, Darawa and HadariKoramas (streams). It drains majorly through the main control overflow structure towards Dantsido (Dauda *et al.*, 2021).

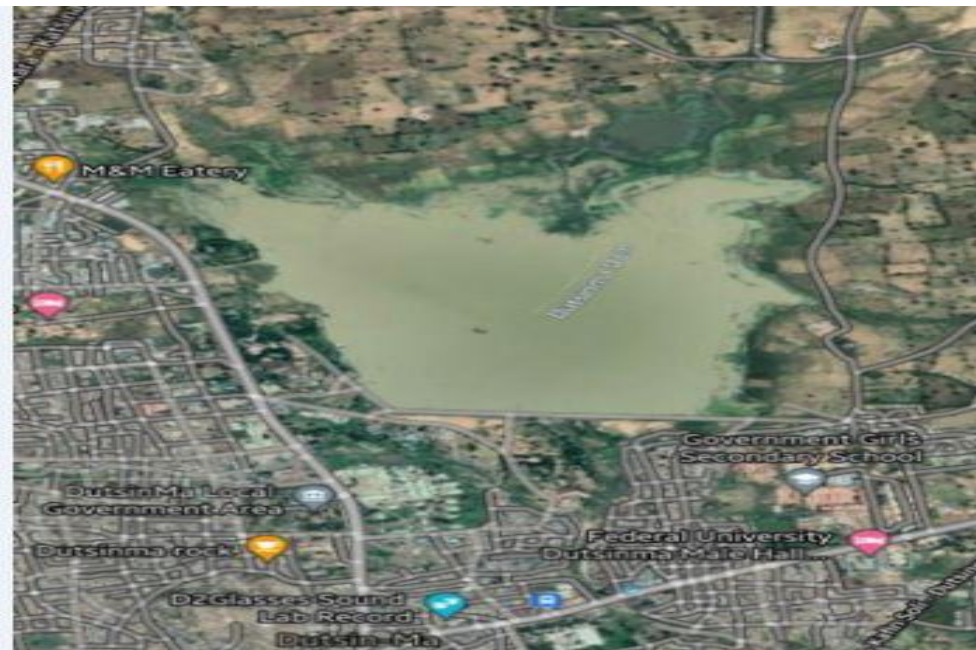


Figure 1: Satellite image of Dutsin-Ma Reservoir Katsina State
Source: Dauda *et al.* (2021).

Data collection

Data on fish catch was collected weekly for eight weeks through observation of fishermen's catch in April and May 2021. Three fishermen were selected for the study and their catches were assessed twice a week for the eight weeks. The gears used by the selected fishermen are cast-net and monofilament gillnets. The fish species were identified using guides and keys, both morphometric and meristic as described by Olaosebikan and Raji (2013).

Data analysis

The fish composition and abundance were presented in frequency and percentage, while diversity indices including Shannon wiener, Evenness, and Margalef were evaluated as described by Jenyo-Oni *et al.* (2010). All the analysis was done using Microsoft excel 2013.

Shannon wiener diversity index $(H) = \sum((p_i) \times \ln(p_i))$

Evenness = H/H_{max}

The Margalef diversity index $(d) = (S - 1) / \ln N$

Where:

Pi is the proportion of the species i relative to the total number of species.

Ln(pi) is the natural logarithm of this proportion (pi)

S = number of species = species richness

Hmax = Ln(S) = maximum diversity possible

N is the total number of individuals in the sample

Results and Discussion

The results of the ichthyofauna composition and abundance of the Dutsin-ma reservoir are shown in table 1, a total of three families, seven genera and twelve species were observed. The family Cichlidae have five of the seven genera and seven of the twelve species reported. The observed number of families can be regarded to be generally low compared to five, eight and six reported from others though bigger water bodies in the state (Ahmad *et al.*, 2014). Nazeef *et al.*, (2018) also reported nine families in Challawa gorge from nearby Kano State. However, the number of species reported in this study is higher than eight species from the

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Ajiwa reservoir, similar to twelve reported in Zobe from the same local government but lower than nineteen reported from the Jibiya reservoir by Ahmad *et al.* (2014). It is also higher than ten species reported in Challawa gorge reservoir of Kano State. The fish abundance showed Cichlidae as the most abundant family with *Sarotherodon galilaeus* as the most abundant species with 34.6 % followed by *Oreochromis niloticus* with 29.8%. Ahmad *et al.* (2014), also reported Cichlidae as the most abundant family in all the three water bodies studied. On the contrary, the researchers reported *Bagrus bayad* as the most abundant species in all the water bodies from the same state. *Sarotherodon galilaeus* was also reported as the most abundant species in the Ikere-gorge dam in Oyo State (Ajagbe *et al.*, 2021). However, the complete absence of Bagridae, the dominant species in other water bodies in the state deserves further study, perhaps through trying of other fishing gears.

Table 1: Composition and Abundance of Ichthyofauna species in Dutsin-Ma Reservoir Katsina State

Family	Genus	Species	A		B		C		Total	
			No.	%	No.	%	No.	%	No.	%
Clariidae	Clarias	<i>Clarias gariepinus</i>	91	3.2	114	4.2	148	4.9	353	4.1
		<i>Clarias angularis</i>	42	1.5	55	2.0	38	1.3	135	1.5
									488	5.7
Cichlidae	Oreochromis	<i>Oreochromis niloticus</i>	903	31.4	763	28.1	900	30.0	2568	29.8
		<i>Oreochromis aureus</i>	85	3.0	124	4.6	99	3.3	308	3.5
	Coptodon	<i>Coptodon zillii</i>	407	14.1	365	13.5	483	16.1	1255	14.6
		<i>Coptodon dageti</i>	73	2.5	86	3.1	105	3.5	264	3.1
	<i>Sarotherodon</i>	<i>Sarotherodon galilaeus</i>	1056	36.7	959	35.4	959	32.0	2974	34.6
	<i>Henichromis</i>	<i>Henichromis faciatus</i>	61	2.1	72	2.7	48	1.6	181	2.1
	<i>Palmatolapia</i>	<i>Palmatolapia mariae</i>	41	1.4	59	2.2	71	2.3	171	1.9
									7721	89.9
Cyprinidae	Labeo	<i>Labeo tibetii</i>	61	2.1	45	1.6	77	2.6	183	2.1
		<i>Labeo senegalensis</i>	35	1.2	48	1.8	35	1.2	118	1.3
		<i>Labeo pseudocoubie</i>	21	0.7	21	0.8	37	1.2	79	0.9
									380	4.4
Total	3 7	12	2,878	100	2,711	100	3,000	100	8589	100

Diversity of Fish Species in Dutsin-Ma reservoir

Table 2 showed the diversity indices of ichthyofauna species in the Dutsin-ma reservoir in Katsina State. The indices revealed a diversified ecosystem accommodating 12 fish species, 7 genera though a low number of families. The Shannon Wiener (H') values 1.43, 1.81 and 1.81 respectively for fisher folks A, B and C indicated a well diversified community, with higher diversity in the catches from the fishers B and C. The Evenness (E) based on the values 0.58, 0.73 and 0.73 respectively for fisher folks A, B and C indicated the species were equally common to the catches from fishers B and C. The Margalef (D) values 1.38, 1.39 and 1.37 respectively for fisher A, B and C indicated similarity among all the catches. The species analysis generally revealed high species diversity and richness. In comparison, species diversity (n=12) in this preliminary study was higher compared to other freshwater bodies in Nigeria like that of Usoma reservoir and Challawa gorge (n=11; Ataguba *et al.*, 2014 and n=10 Nazeef *et al.*, 2018, respectively) but was low compared to that of Apodu reservoir (n=17; Oladipo *et al.*, 2018). All measures of community structure (species diversity, evenness and richness) were generally higher in the reservoir. This can be attributed to the morphology of the reservoir which is characterized by rocky substratum interspaced by boulders which increase habitat heterogeneity resulting in greater habitat niches (Mwangi *et al.*, 2012). Increased riverine habitat heterogeneity was associated with higher fish assemblages in the African river basin (Kadye and

Marshal, 2006). Research has also shown that a more diverse ecosystem is better able to withstand environmental stress and is consequently more productive than a less diverse ecosystem (Patrick and Strydom, 2007).

Table 2: Some Indices of Fish Species in Dutsin-Ma Reservoir Katsina State

Diversity indices	A	B	C	Overall
Shannon wiener index (H)	1.43	1.81	1.81	1.68
Evenness (E)	0.58	0.73	0.73	0.68
Margalef value (D)	1.38	1.39	1.37	1.38

CONCLUSION

This preliminary study established that the Dutsin-ma reservoir comprise diversified fish species with *Cichlidae* as the dominant family in terms of species and number of individuals. Presently, the fish yields from this reservoir are encouraging compared to similar-sized reservoirs or lakes. However, fishing pressure, unregulated fishing gears and lack of conservation management are serious threats to the overall health and biodiversity of the reservoir.

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FISHERIES SURVEY AND STOCK ASSESSMENT OF LAKE NDAKOLOWU, NIGER STATE, NIGERIA

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ABSTRACT

Fisheries information on Lake Ndakolowu (otherwise known as Tatabu Lake) was collected between August 2021 and January 2022. The main objective of the study is to update information on the fish catch composition, yield as well as the fishing gears and craft of the lake. A frame survey (FS) and a catch assessment survey (CAS) were undertaken. Five fishing localities, 10 fish landing sites and 31 fish species were identified. This is considered good for the Lake, however, the Lake's 21.3 fishers/km² is far above recommended standard. Hence, there is need for a communal effort geared at improving the fisheries of the Lake.

Keywords: Lake Ndakolowu; Stock assessment; Frame survey; Catch assessment survey; Gillnetting.

Introduction

A major constraint to science-based fish stock management in Nigeria and the West African sub-region as a whole is the lack of reliable data on target stocks. This specifically holds true for inland fisheries, such as those that operate in reservoirs. Due to the low availability of resources and population data, and the limited number of fisheries experts in the region, state institutions and investigators rely heavily on simple catch statistics and empirical models for their estimations of fish production and potential yields.

Tatabu Lake is a floodplain lake of the River Niger downstream of Jebba Dam, located between latitude 9° 12" – 9° 14"N and longitude 4° 52" – 4° 58"E in Tatabu village along the Ilorin – Mokwa road in Mokwa Local Government Area (LGA) of Niger State, Nigeria. According to Ita (1993) some interesting fisheries studies have been carried out by the National Institute for Freshwater Fisheries Research (NIFFR) between 1977 and 1979 on this Lake. In 1971 the surface area of the Lake was estimates at 9 km² and by 1977 it was reduced to 6 km². By 1979 the area was much less than 6 km² and after the completion of Jebba Dam in 1983 the open water of the Lake was completely obliterated and it was reduced to pockets of overgrown swamps. In April 1988 the Lake completely dried up. The embarkment along the River Niger was excavated down to the level of water in the river in order to permit inflow of water into the Lake during the flood. This was successful and in September 1988 the Lake was restored with increased fish landings (Ita 1993).

Besides the Niger River, three other streams (Emigi, Gbadako and Bisan) run from southeastern direction and empty into the Lake. Emigi and Bisan are seasonal streams that empty into the lake during flood while Gbadako supplies the Lake all year round. The Lake is surrounded mostly by Nupe-speaking communities. DFID/FAO (2004) is credited for the most recent study of the fisheries of Lake Ndakolowu. This study is therefore timely in order to determine the current fish structure and production with a view to enhancing the water body mainly to meet the National goal of increased inland fish production and food security for improved livelihood of the people of the communities surrounding the Lake.

Materials and Methods

1) Frame Survey

A village based structured questionnaire was used. The method of Abiodun *et al.* (2015) was adopted. All the fishing communities around the reservoir were visited and data were gathered through direct observation and interviews with the leader of the fishers (*Sarkin-ruwa*) and some randomly selected fishers. Total count and listing of all fishing villages, fishers, landing sites and fishing units including their fishing equipment such as crafts and gears operating on the reservoir were made.

2) Stock Assessment

Two methods of fish stock assessment surveys were simultaneously employed on the reservoir in order to determine the species composition and estimate the annual yield. The methods include:

- i) Experimental Gillnetting and
- ii) Fish Catch Assessment Survey

i) Experimental Gill Netting

This was done using three (3) fleets of experimental gillnets each comprising of different mesh sizes (1', 1½', 2', 2½', 3', 3½', 4', 5' and 7') that is 50m long and 3m deep. The nets were set at randomly chosen sampling sites, which were checked in the morning and evening for day and night catches respectively. Fish caught were collected according to mesh size, identified and sorted to species using the manuals by Idodo-Umeh (2003) and Olaosebikan *et al.* (2021). Fish were counted, weighed using weighing balance, lengths measured with measuring board and recorded accordingly.

ii) Fish Catch Assessment Survey

The procedure followed by Abiodun *et al.* (2015) was used for this CAS. After a reconnaissance survey of the whole lake to explore fishing settlements and landing sites, a detailed examination and recording of the content of every canoe that had just landed on returned from a fishing trip was carried out for three consecutive days at randomly selected landing sites. As a fisherman landed his canoe on the beach, the fish caught is examined and sorted according to species and the gear type used to make the catch.

Results and Discussion

1. Frame Survey (FS)

From the FS, there were five fishing communities located mainly in the Northwestern part of the lake. These are *Tatabu*, *Tsafa*, *Yagi Tatabu*, *Tunga Ruwa* and *Lafiagi Santi*. It was understood that a few scattered temporary fishing camps also exist on the Northeastern part but has been flooded by the high-water tides of the rainy season. Table 1 shows the distribution of the fishers, their fishing craft and gears. Altogether, a total of 213 fishers with 129 assistants were enumerated. *Tatabu* had the largest concentration of fishers with a total of 93 and 12 assistants. All fishers of the lake are males as it is a taboo for females to fish on the lake. All the fishers are considered full-time as all of them have their own craft and gears, and also go into fishing at least for two weeks or more in every month of the year. However, they also engage themselves in arable and animal husbandry.

For an optimum catch and viable economic return, 2 full-time fishers per square kilometres were recommended for most African Inland waters by Henderson and Welcomme (1974). Based on this recommendation, about twenty (20) full-time fishers would be required for Tatabu Lake with an approximate maximum water surface area of about 10km² (Ita, 1993). However, a total of 213 full-time fishers were recorded in the Lake. There is a very strong community regulation on the use of only gill nets, traps and long-lines on the lake.

Table 1: Frame data of Tatabu Reservoir

Locality	No. of Fishers	No. of gears

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	No. of landing Sites	Males	Assist.	No. of canoe	GN	LL	TR
<i>Tatabu</i>	5	93	12	97	355	51	27
<i>Tsafa</i>	2	31	3	31	126	96	87
<i>Tunga Ruwa</i>	1	29	37	39	118	27	238
<i>Yadi Tatabu</i>	1	37	31	47	158	26	75
<i>Lafiyagi Santi</i>	1	23	46	37	53	92	516
Total	10	213	129	251	810	292	943

Keys:GN=Gill net; LL=Longline; TR=Traps

The main fishing craft used on Tatabu Lake are the flat-bottom planked canoe. Altogether, 251 canoes were enumerated with the highest concentration of 97 found at Tatabu. None of these canoes is motorized. This is intentional by the fishers of the Lake, mainly to avoid the disruption of their fellow fishers' gears, such as the gillnets and longlines, which are in abundant use on the Lake.

2. Stock Assessment

Table 2 shows fish species composition, abundance and diversity of Lake Ndakolowu, Niger State. Thirty-one (31) species of fish from thirteen (13) families were recorded in this study. Species diversity on the Lake according to Daddy and Awojodu (1991) recovered from 9 to 25 species, whereas Raji *et al.* (2008) revealed 71 species from 25 families. Though this suggests a decrease in fish diversity when compared with Raji *et al.* (2008), it also shows an improvement over the finding of Daddy and Awojodu (1991).

The family Mormyridae with seven (7) species was the most diverse while Claroteidae and Mochokidae, each with four (4) species, were next. Schilbeidae, Distichodontidae, Latidae, Polypteridae. Cyprinidae and Gymnarchidae had one (1) species each.

Brycinus longipinnis was the most abundant species contributing 26.65% of the catches followed by *Schilbe mystus* with 18.21%. *Mormyrus macrophthalmus*, *Mormyrops anguiliodes*, *Chrysichthys nigrodigitatus*, *Auchenoglanis occidentalis*, *Auchenoglanis biscutatus*, *Distichodus rostratus* and *Gymnarchus niloticus* each contributed only 0.26%. Although, *Gymnarchus niloticus*, which recorded lowest number contributed the highest weight (14.24%). This implies that fish with highest number does not necessarily contribute the highest weight, hence the importance of the species to the fishery of the lake. This was followed by *Lates niloticus* (14.06%) while *Chrysichthys nigrodigitatus* and *Clarotes laticeps* each contributed only 0.17%.

Table 2: Fish composition, abundance and diversity of Lake Ndakolowu, Niger State

Family/species	No	%No	Wt (g)	% Wt
Schilbeidae				
<i>Schilbe mystus</i>	69	18.21	824	13.80
Cichlidae				
<i>Hemichromis fasciatus</i>	2	0.53	20	0.34
<i>Hemichromis bimaculatus</i>	4	1.06	50	0.84

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<i>Chromidotilapia guentheri</i>	2	0.53	30	0.50
Mormyridae				
<i>Hyperopisus bebe</i>	2	0.53	75	1.26
<i>Marcusenius psitatus</i>	13	3.43	100	1.68
<i>Mormyrus macropthalmus</i>	1	0.26	20	0.34
<i>Petrocephalus bovei</i>	5	1.32	70	1.17
<i>Mormyrus rume</i>	9	2.37	300	5.03
<i>Mormyrops anguiliodes</i>	1	0.26	30	0.50
<i>Marcusenius senegalensis</i>	13	3.43	50	0.84
Alestidae				
<i>Hydrocynus forskalii</i>	7	1.85	390	6.53
<i>Alestes baremoze</i>	2	0.53	20	0.34
<i>Brycinus longipinnis</i>	101	26.65	400	6.70
Claroteidae				
<i>Chrysichthys nigrodigitatus</i>	1	0.26	10	0.17
<i>Clarotes laticeps</i>	2	0.53	10	0.17
<i>Auchenoglanis occidentalis</i>	1	0.26	80	1.34
<i>Auchenoglanis biscutatus</i>	1	0.26	40	0.67
Distichodontidae				
<i>Distichodus rostratus</i>	5	1.32	90	1.51
Latidae				
<i>Lates niloticus</i>	20	5.28	840	14.06
Polypteridae				
<i>Polypterus senegalus</i>	2	0.53	60	1.01
Bagridae				
<i>Bagrus docmac</i>	18	4.75	150	2.51
<i>Bagrus bayad</i>	7	1.85	590	9.87
Cyprinidae				
<i>Labeo coubie</i>	2	0.53	50	0.84

Table 2 Cont'd

Family/species	No	%No	Wt (g)	% Wt
Mochokidae				
<i>Synodontis membranaceus</i>	8	2.11	100	1.68
<i>Synodontis nigrita</i>	7	1.85	120	2.01
<i>Synodontis shall</i>	3	0.79	66	1.11
<i>Synodontis nigrita</i>	2	0.53	110	1.84
<i>Synodontis eupteus</i>	67	17.67	375	6.27

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Distichontinae				
<i>Distichodus rostratus</i>	1	0.26	50	0.83
Gymnarchidae				
<i>Gymnarchus niloticus</i>	1	0.26	850	14.24
Grand Total	379	100	5970	100

The family Alestidae dominated the catch in the lake followed by Mochokidae, which shows their importance to the fishery of the lake contributing 29.03% and 22.95% respectively of total catch. The families Distichodontidae and Gymnarchidae only contributed 0.26% each (Table 3). In terms of weight, Gymnarchidae recorded the highest weight (14.24%) followed by Latidae (14.06%) then Cyprinidae and Distichodontidae with each contributing only 0.83% of the total weight. Otobo (1977), reported the dominant fish family by weight in the Lake as the Osteoglossidae, closely followed by the Cichlidae, Hepsetidae, Gymnarchidae, Clariidae and Mochokidae. The current study shows that these fish families still play prominent roles in the lake.

3. Mesh size Selectivity

Table 4 shows the catches on Lake Ndakolowu based on net meshes. Mesh size 1" contributed the highest catch in terms of number (80.21%) and weight (40.18%). This was followed by 2" both in number (7.40%) and weight (15.91%) while mesh size 4" contributed lowest in number (0.26%) and weight (14.24%). This is an indication that smaller mesh size had more catch than bigger meshes size on the lake, which reflected on the sizes of fish caught during the period of this study. The recommended mesh size for gillnet fishing is 3" and above. However, bulk of the catches fall short of such recommendation. The current fish yield of the lake is 2.30kg/ha is considered to be low when compared with other reservoirs in the same geological zone. During the period of study, the lake experienced flood with lots of grass mat, which affected fishing activities resulting to a low catch, but there was improvement on the catches as water receded. This could have contributed to the low yield observed.

Table 4: Fish catch based on net meshes on Lake Ndakolowu, Niger State

Mesh size	Total number	%Total number	Total weight	%Total weight
1"	304	80.21	2,399	40.18
1½"	28	7.40	865	14.49
2"	35	9.23	950	15.91
3"	11	2.90	906	15.18
4"	1	0.26	850	14.24
Total	379	100	5,970	100

CONCLUSION AND RECOMMENDATION

The frame survey in this study revealed that the density of fishers on the lake (21.3 fishers/km²) is far above the recommended standard by Henderson and Welcomme (1974). Hence, there is need for a communal effort geared at improving the fisheries of the lake.

The results of the study revealed thirty-one (31) species belonging to thirteen (13) families recorded in the lake. Fish diversity of the lake is relatively high compared to other water bodies within the same region. Family Mormyridae ranked highest in diversity with seven (7) species while the families Gymnarchidae, Schilbeidae, Distichontidae, Latidae, Polypteridae, Cyprinidae are recorded lowest with one species each. Alestidae was dominant in terms of number with Gymnarchidae in terms of weight. *Brycinus longipinnis* was the dominant species with *Gymnarchus niloticus* having highest weight. Bulk of the fishes was caught

on meshes below the 3" recommended sizes for inland water bodies of the country. The current fish yield (2.30kg/ha) for the lake based on experimental gillnetting is very low. It is therefore recommended that, more awareness on better fishing methods on the Lake, like putting a ban on the use of nets with mesh sizes below 3", be created for the community.

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REFLECTING ONTO THE POPULATION DYNAMICS OF *Glyptothorax exodon*: MIGHT IN RARITY

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ABSTRACT

The population dynamics of *Glyptothorax exodon* from Dadin-Kowa reservoir were studied. Population dynamic parameters such as growth, mortality and recruitment patterns were analyzed using length frequency data over 12-month period employing FiSAT II software. Findings revealed that $K = 1.0^{-yr}$, $L_{\infty} = 19.22$ cm and $T_{max} = 3$ years. Mortality indices revealed that the fish is slightly above exploitation threshold ($F > E_{opt} \leq 0.5$). However; the major source of population decay is associated with natural factors ($M = 76\%$). Single recruitment peak was observed with $L_m = 12.8$ cm. Restocking program is suitable to ensure its continuous existence as it seems to have low population. It's rarity, bright coloration and relative small size can pave way to classify the fish as ornamental as well as threatened species.

Keywords: Fish population dynamics, *Glyptothorax exodon*, FiSAT II, Natural Mortality, Dadin-Kowa Reservoir.

INTRODUCTION

Fish population is subject to natural control processes and a renewable resource if they are exploited in a planned manner (Mayank, Rizvi, & Dwivedi, 2017). Despite its benefits and tremendous species diversity; fish resources have witnessed various changes in stock diversity and abundance resulting from structural changes in habitat, food composition and uncontrolled exploitation (Ayamre & Ekelemu, 2016).

Fish population dynamics indicates the fluctuations or changes in number of fish in a given population and the factors responsible for these changes including the rate of loss (death) and replacement of individuals (recruitment) in the population and any other regulatory forces tending to keep the number in the population steady at least to prevent excessive changes (Assi *et al.*, 2018). Data obtained from fish population changes

describe the rate of reproduction, rate of growth, rate of mortality, rate of recruitment, change in size and number that occur to fishery resources overtime. Population dynamics further describes the ways in which a population increases and decreases that affect optimal harvesting rates. Fish population dynamics is used by fisheries scientists to determine sustainable yields (Amponsah, Ofori-danson, Nunoo, & Ameyaw, 2019). Fish populations have a unique set of dynamics (these are: Recruitment, Growth, and Mortality) that influence their current and future status (Food and Agriculture Organization, 2019).

Over 90% of the fish stocks in the world are managed without formal stock assessment and the distribution patterns, biology of many fish species that are exploited are inadequately studied or unknown entirely, as a result, stocks may be depleted even before we have chance of knowing their biological roles in the ecosystem (Ambily, 2016; Dinh, 2017). *Glyptothorax exodon* indicated a rarity in abundance which entailed the current studies to unearth its population parameters and its potential availability in the future.

MATERIALS AND METHODS

The study area: The Dadin-Kowa is located in Yamaltu-Deba Local Government area, Gombe State in the north east of Nigeria. Dadin-kowa town is located between Latitudes 10°19'19"N and 10.32194°N; Longitude 11°28'54"E and 11.48167°E. It shares common boundary with Akko Local Government area, to the South and West, Yamaltu-Deba to the East and Kwami to the North. Dadin-kowa has an altitude of about 370 meters above sea level (Nazeef & Abubakar, 2013).

Data Collection

Fish samples were collected from three prominent landing sites on a monthly basis for the period of 12 months (January - December, 2020) from the catches of artisanal fishermen. The three landing sites were: Almakashi: 10°44'40.584"N, 11°30'32.574"E, Dadin-Kowa: 10°92'14.142"N, 11°28'43.956"E and Malleri: 10°18' 38.539"N, 11°9'13.582"E. The study area has bordered three local government areas of Gombe State each with at least a town having intensive fishing activities, therefore, the aforementioned landing sites were selected reflecting the entire Reservoir coverage, and the local government areas includes Funakaye (Almakashi); Yamaltu-Deba (Dadin-Kowa) and Kwami (Malleri) accordingly.

Fish samples were sampled from the population and their morphometric measurements (Standard length & weight) were measured using a measuring tape and a digital weighing balance (Sartorius) to the nearest 0.1cm and 0.1g respectively. The standard lengths of each of the fish species measured from the three landing sites was pooled monthly (Ahmad, Yola, & Nazeef, 2018) and grouped into classes of 2-cm constant class sizes using the **FiSAT_II** software for subsequent analyses.

Growth determination:

The length frequency data was used to plot **Powell-Wetherall Plot** (Dong, Xiang, Ju, Li, & Ye, 2019) which was then used to obtain the initial asymptotic length (L_{∞}), Z/K = which is the ratio between total mortality and growth speed towards L_{∞} . Also, fish species hypothetical longevity or T_{max} was determined employing the function; Longevity (T_{max}) = $3/(K)$, where K = VBGF growth constant, or coefficient of growth.

Recruitment determination:

The recruitment rate was estimated by backward projection, as illustrated in the FiSAT routine, along a trajectory defined by the Von Bertalanffy Growth Function; of the length-frequencies onto the time axis of a time-series of samples using the original data, as described in the FiSAT routine. Inputs for the recruitment determination includes growth parameters such as L_{∞} , K and t_0 (if available). Recruitment pulses were obtained, which is/are the month(s) with the highest percentages of recruitment as an output (Asriyana *et al.*, 2020). Also, the length at first maturity (L_m) was determined employing the function: $L_m = L_{\infty} * 2/3$ (Wehye, Ofori-danson, & Lamptey, 2017).

2.4 Mortality Parameters determination:

Employing the *Pauly M's Equation*; the Total mortality rate (Z) was estimated using *Length-Converted Catch Analysis* taking 25°C as the mean annual surface temperature of the Reservoir. The Natural mortality rates (M) were estimated using Pauly M's equation. Outputs of the process besides Z and M ; includes the Fishing mortality (F) and Exploitation ratio (E). Data inputs for the analysis includes $\ln(M) = -0.0152 - 0.279 \ln(L_{\infty}) + 0.6543 \ln(K) + 0.463 \ln(T)$. Where; L_{∞} = Asymptotic length, K = VBGF growth constant, T = Mean annual surface temperature (Wehye *et al.*, 2017).

RESULTS AND DISCUSSION

Growth parameters:

Data obtained for the parameters of growth for *Glyptothorax exodon* indicated that asymptotic length (L_{∞}) = 19.22 cm, growth speed (K) is 1.0-yr^{-1} , and potential longevity ($T_{\max}$) is 3 years accordingly (Figure 1).

Mortality parameters

The parameters of mortality with respect to the said fish species revealed that Total mortality (Z) stood at 2.52-yr^{-1} , Natural mortality (M) is 1.92-yr^{-1} and Fishing mortality (F) is 0.60-yr^{-1} . However, the Exploitation ratio (E) is 0.24-yr^{-1} (Figures 2 and 3).

Recruitment patterns:

Reflecting on the recruitment pattern of the said fish indicates a single recruitment peak stretching from April (26.9%) to May (24.1%), whereas the month of August recorded the least recruitment output with 0.44% of the fish's population. However, the L_m obtained was 12.8 cm accordingly (Figure 4).

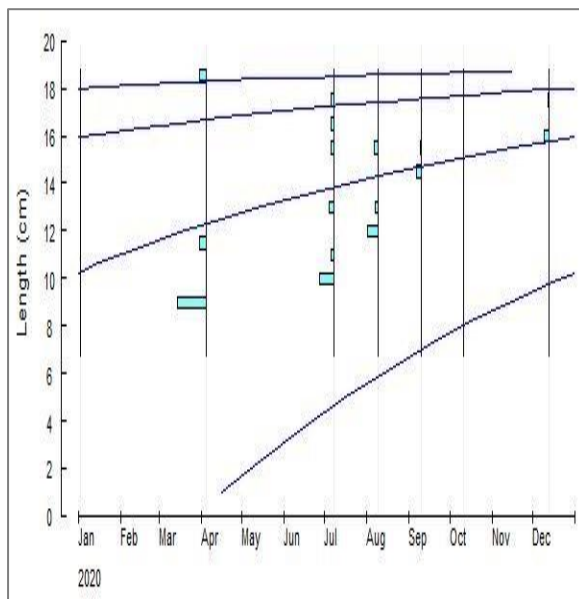


Figure 1: Seasonally oscillating restructured length frequency histogram superimposed with growth curve of *Glyptothorax exodon*

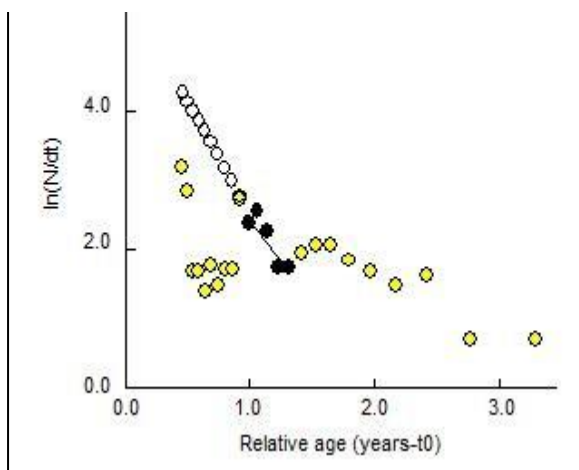


Figure 2: Length converted catch curves displaying the mortality patterns and exploitation rates of *Glyptothorax exodon*

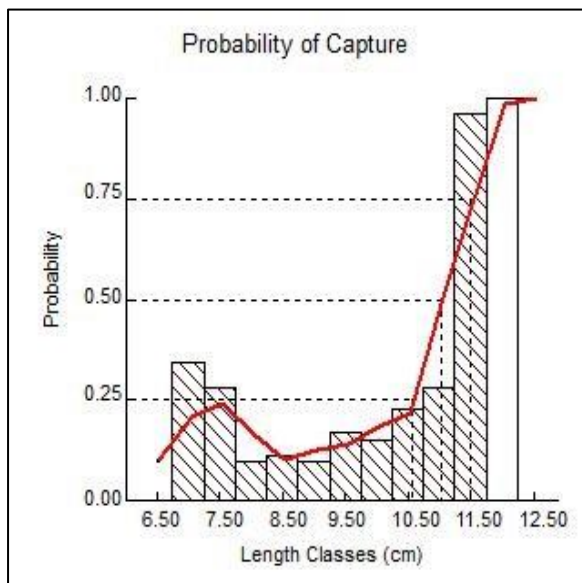


Figure 3: Probability of capture of *Glyptothorax exodon*

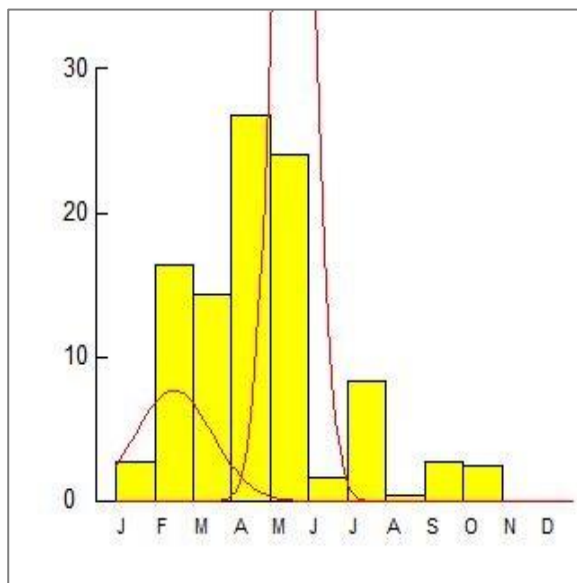


Figure 4: Monthly recruitment patterns of *Glyptothorax exodon*

Growth: The fish species has no related literature in all available databases. The growth coefficient index ($K = 1.0$) can be associated with the small population number, yielding to less intra-specific competition. Potential longevity (life-span or $T_{max} = 3.0$) is said to be moderate. Asymptotic length for this fish species is 19.22 cm, this value is however greater than 12.6 cm recorded by Tran and Dinh, (2020) on *Periophthalmodon septemradiatus* from Vietnam. This implies that adaptation of this fish species to this habitat had aided its establishment.

4.2 Mortality and recruitment pattern: L_C , L_m and L_{opt} were relative equal which indicates an ideal or stable population status. But E_{max} (Y/R and B/R) and F_{opt} (0.74 and 0.76) suggested an increase in fishing effort because the biomass accumulation and optimal fishing mortality could not be realized due to largely inaccessible lost biomass through natural causes ($M = 76.19\%$). These causes can be either through one or combination of all the natural causes of population decay such as competition, senescence, predation, pollution and disease pressure. However, the population of this species from the obtained Exploitation rate (E) value is understood to be underexploited ($E < E_{opt} 0.5$) but susceptible to mortality dominance. This is because $Z/K > 1$, this is largely associated with natural mortality ($M = 1.92$) than fishing activity. While M/K is typical of African fish species, the reproductive load (L_C/L_{∞}) is optimal for the replenishing lost population if given the chance. The recruitment of this fish species is all year round with single major peak occurring within February to May and the L_m is 12.8cm. Z/K value is comparable to that of Kindong *et al.*, (2020), Z is similar to the findings of (Ama-abasi & Uyoh, 2020). E -value aligned to outcomes of *Dactylopterus volitans* (da Costa, Tubino, & Monteiro-Neto, 2018). And (Amponsah, Ofori-danson, Nunoo, & Ameyaw, 2016) inferred L_C/L_{∞} similar to this findings.

Conclusion:

Despite the major population decay emanating natural mortality factors ($M = 76.19\%$); the Dadin-Kowa reservoir is considered to be a suitable habitat for *Glyptothorax exodon*. It is evident that it's rare in existence and the population parameters analyzed revealed slight over exploitation. If given the right management practices; it is believed that the fish can strive better in the future.

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CHARACTERIZATION OF *Oreochromis niloticus* AND *Croptodon zillii* OF LAKE ASEJIRE, NIGERIA

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ABSTRACTS

Oreochromis niloticus and *Coptodon zillii* of Lake Asejire were characterized using the morphomeristic features. The species were found to vary with their counterparts. The *O. niloticus* of Asejire had D-11-13, XVI-XVII, A-10, III FAO species profile were D-11-15, XVI-XVII, A-11-15, III. *C. zillii* of Asejire had D-9-15, XI- XVII, A- 7-10, III-V while those in Fishbase were D-10-14, XIII-XVI, A-8-10, III.

Keyword: Species, Morphometrics features, comparison, lake, Cichlids.

Introduction

Cichlids are primarily freshwater fishes found in tropical waters, such as Central and South America, mainland Africa, Madagascar and Southern Asia. They are basically freshwater with a few brackish water species (Fishbase, 2022 and Britanica, 2017) with only one known true marine species *Tilapia guineensis* (Günther, 1862). They occur in great diversity in major African Lakes. They are generally deep-bodied, have one nostril on each side of the head and a discontinuous, lateral line (Britanica, 2017). They are well noted for their complex mating behaviour and breeding strategies, which makes them invasive. Over 1,300 species of Cichlids have been identified in tropical waters.

Morphometric and meristic characters are common feature used to identify stocks of fish and detect differences between fish populations (Teugels,1982; Turan *et al.*,2004, Buj *et al.*, 2008 and Torres *et al.*,2010). Morphometric parameters are measurable characters such as total length, snout length, body depth, standard length and body weights while meristic parameters are countable features some of which are related to movement, balancing and other activities, they include the fin rays, spines and gill rakers.

The characterization of these species in Asejire lake is important as it will provide information on the uniqueness or otherwise of the breed that are resident in the lake. It will also provide information on whether or not there has been interbreeding among the species.

Materials and Methods

- Study Area

Asejire lake is a man-made lake located in Oyo State about 30 kilometres east of Ibadan in the South-West of Nigeria on the Osun River, one of the major rivers that drain the western part of Nigeria. The Lake lies between Latitudes 7°23'N and 7°35'N and longitudes 4°8'E and 4°14'E. It has an estimated surface area of 15.4km², which is about 525ha. The maximum depth is 19m and the catchment area covers about 7175km². Farming is totally banned in the catchment area and the trees have been planted on the banks, so erosion and silting are not issues. The reservoir remains full throughout the year with plenty water supply.

- SAMPLING

The fish species for this study were collected fortnightly for 12 months using monofilament gill net of 40mm-60mm set at random location on the water body with the help of a registered fisherman. Below are the pictures of species that were identified and characterized;



Plate 1: Picture of *Oreochromis niloticus*



Plate 2: Picture of *Coptodon zillii*

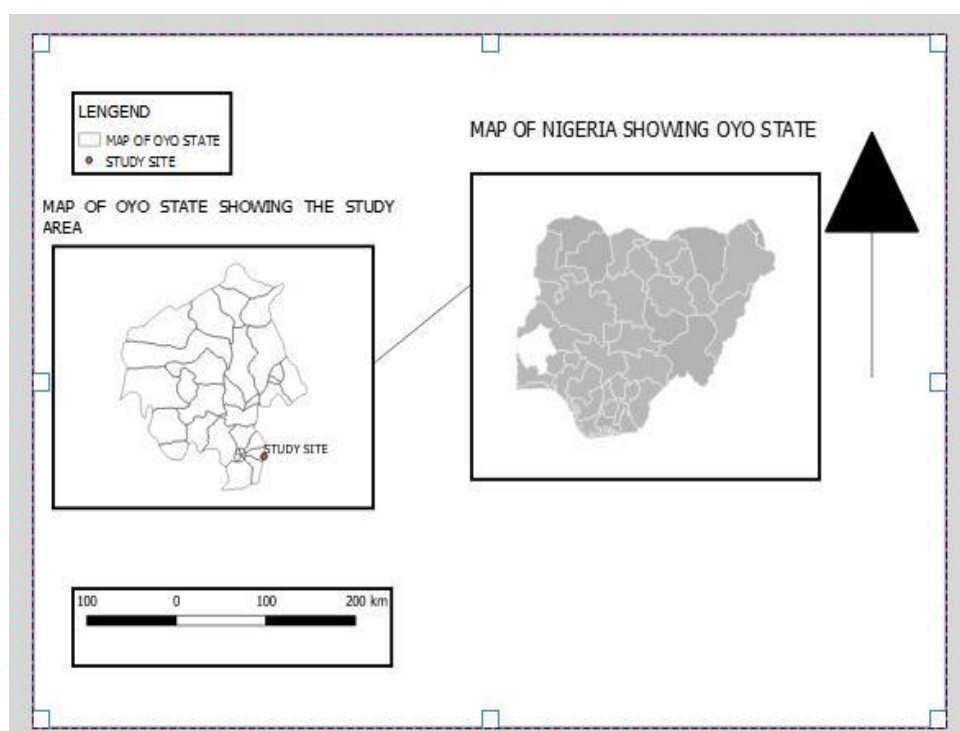


Figure 1: Map of Oyo state showing the study area in Asejire Lake, South-West Nigeria.

• MORPHOMETRIC MEASUREMENT

Morphometric and Meristic parameters were measured on each sample with the aid of measuring board, measuring rule, weighing balance: Standard length [SI], total length [TL], weight [Wt], body depth, pre anal length, girth length, pre pectoral length, head length, pre orbital length, post orbital length or snout length, pre dorsal length were measured in centimeters [cm] and grams [g] and were recorded on data collection sheet for each sample separately accordingly.

COMPARISON AND IDENTIFICATION OF FISH SAMPLES

- Samples were identified and compared with the use of Fresh and Brackish Water Fishes of West Africa (Paugy *et al.*, 2003), FAO (2009) and Froese and Pauly (2022).

Results and Discussions

Mean values of the morphometrics of *Coptodon zillii*, *Oreochromis niloticus* in Asejire Lake. Table 1 below shows the morphometrics mean and values which includes the following characters ; sex, gill raker, total length, standard length, weight, head length pre anal length, pre pectoral length, body depth, predorsal length and pre orbital length.

Table 1: Mean values of morphological features of *C. zillii* and *O. niloticus*

	<i>C. zillii</i>	<i>O. niloticus</i>
Characters	mean±S.D	mean±S.D
Weight	201.87±138.42 ^a	254.13±217.13 ^a
Total Length	17.93±5.45 ^a	17.39±7.06 ^a

Standard Length	14.05±4.16 ^a	13.68±5.99 ^a
Pre anal length	10.80±4.22 ^a	10.26±4.39 ^a
Pre pectoral length	4.42±1.34 ^a	4.37±1.99 ^a
Body depth	6.27±1.91 ^a	6.52±2.62 ^a
Pre dorsal length	5.32±1.35 ^a	5.16±1.85 ^a
Pre orbital length	1.45±0.51 ^a	1.39±0.58 ^a
Post orbital length	1.27±0.45 ^a	1.17±0.55 ^a
Head length	4.61±1.42 ^a	4.49±1.81 ^a
Dorsal rays	11.27±1.27 ^a	11.25±1.82 ^b
Dorsal spines	15.04±1.74 ^b	15.23±1.42 ^b
Anal rays	8.65±1.35 ^{bc}	8.98±1.04 ^{bc}
Anal spines	3.27±0.71 ^{ab}	3.39±0.89 ^b
Pectoral fin	11.13±2.05 ^b	11.64±1.73 ^{bc}
Pelvic rays	5.02±0.30 ^a	5.04±0.29 ^a
Pelvic spines	1.15±0.36 ^b	1.10±0.31 ^a
Caudal fin	14.80±1.25 ^a	15.19±1.33 ^b
Gill rakers	11.18±2.44 ^a	22.93±2.09 ^a

Values with different superscript are not significantly different to one another (p<0.05).

The mean values recorded for dorsal fin rays and spines, anal fin ray and spines, pectoral fin, pelvic fin ray and spines differ significantly among the two species(P<0.05).

MERISTIC PARAMETERS OF *Coptodon zillii* AND *Oreochromis niloticus*.

Table 2 and 3 below shows the meristic parameters recorded and compared with those from literature to ascertain the presence in the lake.

Table 2: Meristic parameters of *C. zillii* in Asejire Lake

Parameters	Froese and Pauly (2022)	This study
Dorsal fin rays	10-14	9-15
Dorsal spines	XIII-XVI	XI-XVII
Anal fin rays	8-10	7-10
Anal spine	III	III-V
Pectoral fin	-	11-14
Pelvic fin rays	5	4-6
Pelvic spine	I	II-III
Caudal fin	-	12-19
No of gill rakers on lower part of the anterior gill arch	8-10	10-15

Nine (9) meristic/counts were used to validate the presence of *C.zilli* and *o.niloticus* in Asejire lake (Table 2 and 3), where the comparison shows some differences between the features for this study and those of Froese and Pauly (2022) in FishBase. For instance, the dorsal fin rays of *C. zillii* in Asejire is between 9 -15, but 10 -14 in the species specified by Froese and Paul (2022). Other features also vary.

Table 3: Meristic parameters of *O. niloticus* in Asejire Lake

Parameters	FAO (2022)	This study
Dorsal fin rays	11-15	11-13
Dorsal spines	XVI-XVII	XVI-XVII

Anal fin rays	11-15	10
Anal spine	III	III
Pectoral fin	8-10	11
Pelvic fin rays	6-7	5
Pelvic spine	—	I
Caudal fin	13	16
No of gill rakers on lower part of the anterior gill arch	27-33	20-26

There is variations in the features listed by FAO(2022) in their species profile for *O. niloticus* with this study in the number rays in the pelvic, number of gill rakers and caudal fins.

CONCLUSION

Coptodon zillii and *Oreochromis niloticus* of Asejire Lake vary respectively with their counterparts in Froese and Pauly(2022) and FAO(2022). This variations may be attributable to need of the species to adapt to their respective environments over the years.

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STUDY OF SOME ASPECT OF THE BIOLOGY OF *BAGRUS BAYAD* FROM AJIWA DAM, KATSINA STATE

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ABSTRACT

Study on the aspects of the biology of *Bagrus bayad* length and weight relationship, condition factor and food and feeding habit was carried out between November to December, 2019 from Ajiwa Dam, Batagarawa Local government, Katsina state. A total of 121 *B. bayad* obtained from the fishermen operating on Ajiwa dam were used for the study. These fishermen used various fishing gears including hand nets, cast nets and fill nets of various standard mesh sizes (20.2, 25.4 and 30.5mm). The growth pattern of *B. bayad* was determined on the basis of monthly randomized collection. There is a significant relationship between length and weight of the fish under study with value of $p < 0.0001$. The length – weight relationship of *B. bayad* in this study showed that the fish had a “b” value of 2.7 in September, one showing negative allometric growth, 3.1 in October indicating positive allometric growth, 2.4 in November showing negative allometric growth and 3.0 in December indicating allometric growth pattern. The value of K in this study was 1.2 in week 1, 1.2 in week 2, 1.3 in week 3 and 1.1 in week 4. The K values in this study were greater than 1 indicating that fish species were doing well in the dam. The result on food and feeding habit of *B. bayad* showed that, they feed mainly on fish materials, insect parts, small fishes; plant materials such as wheat bran, leaf parts, seed particles and other include small stone and unidentified food particles. It is recommended that further studies be extended for other native fish species so as to provide the scientific information for their management. The local communities should be oriented with the information on the food and feeding habits of the fish species in their area toward formulation of artificial diets to feed the wild fishes toward improving the fishery sector.

Keywords: Ajiwa dam, Allometric, *Bagrus bayad*, Biology, feeding habits, Growth.

Introduction

Bagrus bayad (daget), a member of Bagridae family is a commercially important fish species found in Nigeria fresh water especially in River Niger, Kaduna, Benue, Lake Chad and other inland water (Olaosebikan and Raji, 1998). It has high growth rate but has not been cultured due to limited information on their biology, breeding and survival under captivity.

Generally, *B. bayad* is probably associated with rocky bottoms; coarse substrates in both shallow and deep water. Alhassan and Ansu-Darko (2011) reported that *B. bayad* is benthic carnivorous feeder (bottom feeder) as they proved the presence of detritus (bottom deposit) in addition to the other food items inside the alimentary tract.

Food and feeding habits of different fishes in many water bodies and stomach contents analysis has widely been adopted as a means of investigating trophic relationship in the aquatic communities (Fagbenro *et al.*, 2000). Food studies revealed the status of foraging, rate of growth and seasonal changes in life history of fish species are useful for their cultivation and exploitation (Ugwumba and Ugwumba, 2007).

Length-weight relationship (LWR) is also an important factor in fish ecology and in the biological study of fishes. It can be an estimation of the average weight of the fish of a given length group by establishing a mathematical relation between the two variables (Tebieira de Mallo 2006).

The Fulton's condition Factor 'K' is used to compare the „condition ‘fitness’ or wellbeing of fish and to determine possible differences between separate unit stock of the same species (King, 2007). The condition factor provides information on the wellbeing of a fish and is usually influenced by the fish, sex, season, maturity stage *e.t.c.* (Anyanwu *et al.*, 2007)..

B. bayad was chosen for the study because the fish has high commercial value in Nigerian fresh water fish markets and have wide spread consumer acceptance.

The aim of this research was therefore to determine the length-weight relationship and condition factor as well as food and feeding habits of *B. bayad* from Ajiwa dam Batagarawa Local Government, Katsina State.

Materials and Methods

Study Area

Ajiwa dam has a geographical location of 12° 59' 0" North, 7° 45' 0" East (Fig.1). The dam was constructed purposely to provide water for human consumption and domestic uses. In addition, secondary activities like irrigation and fishing are taking place.

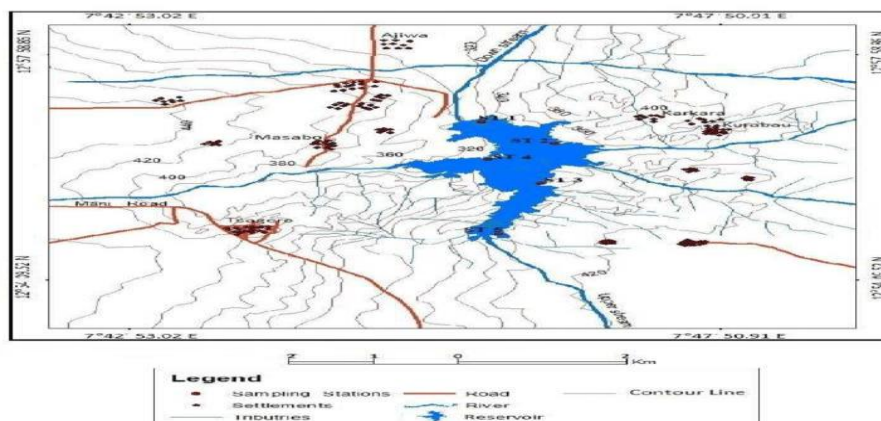


Figure 1: The Map of Ajiwa dam showing the sampling sites (Source: Cartographic Section, Dept. of Geography, Umar Musa Yar'adua University, Katsina, 2019)

Samples Collection

One hundred and twenty one (121) samples of *B. bayad* were purchased randomly at the shore of the dam from the local fishermen in the early morning (8 am- 9am) of the months of September, October, November and December, 2019 respectively. After collection the fishes were placed in a plastic container containing ice water and transported to the department of Biology Umaru Musa Yar'adua University Katsina for further laboratory analysis.

Length weight relationship (LWR)

Lengths and weights of the collected fishes were taken. A sensitive electronic balance (Model number YP 500 IN) was used to measure the weights. The Total Length (TL) of the fish was measured from the tip of the anterior part of the mouth to the caudal fin using meter rule calibrated in centimetres.

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.

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.

Stomach Contents Analysis.

The stomach of each fish was weighed with and without food to determine food weight. Three portions, of cm each, were taken from the anterior, mid and hind part of each gut. The percentage frequency of occurrence (0%) was used to determine the stomach contents and is = the number of stomach in which a food items was found in proportion to the number of all non – empty stomach (number of stomach with food).

Data Analysis

Correlation and regression were used to analyze length and weight relations and percentages were used to determine the amount of food fed by *B. bayad* from Ajiwa dam. The analyses were done with Graph pad statistical software version 6.04. All statistical analyses were considered at significant level of 5% ($p < 0.05$)

Results and Discussion

The length – weight relationship of *B. bayad* from Ajiwa dam for the period of study (Sept.- Nov. 2019) is presented in Table 1.0. There was a significant relationship between length and weight ($r = 0.953$, $p < 0.0001$)

in the month of October. The result indicated a negative allometric growth with b value of 2.7. The Fulton's condition factor ($K = 1.24$).

The major food items found in the stomach of *B. bayad* during the study period were presented in Table 2. These comprises of small fishes, fishes parts, worms, insects parts and unidentified parts with 18.12%, 25.0%, 2.5%, 24.37% and 10.62% respectively.

The results of this study showed both negative and positive allometric growth. This agreed with the findings of Umar and Hassan (2011), where negative allometric growth was observed for *B. bayad* and Ogbe *et al.*, (2006) who reported positive allometric growth pattern for *B. bayad* from lower Benue River. Similarly, Abdulkarim and Jabir (2013) reported both positive and negative allometric growth from Kwanar Are dam, Katsina State.

The K values (condition factor) from this study were all above 1 indicating that *B. bayad* (fish species) are doing well in the dam. This agreed with the findings of (Anyanwu *et al.*, 2007) who noted that condition factor which is an estimate of the general wellbeing or relative fitness (plumpness) of the individual fish may be influenced by age, sex, season and maturity.

The result on food and feeding habit showed that, *B. bayad* feed mainly on fish parts; insects, plant materials such as wheat bran, leaf parts, seed particles and other include small stone and unidentified food particles. This is in agreement with the findings Malami *et al.* (2004) who reported that fish parts were highly consumed by *B. bayad* than other animal followed by insect part.

CONCLUSION

Study on *B. bayad* indicated that the fish grow fast and exhibited both positive and negative allometric growth and feed mostly on fish parts, with few plant materials and therefore recommended the species as a good candidate for aquaculture.

Table 1: Length weight relationship and Condition Factor of *Bagrus bayad* from Ajiwa dam (Sept- Dec., 2019).

Month(s)	Mean length (cm)	Mean weight (g)	N	b	a	R	r	K	Type of Growth	P value
Sept.	13.70	442.22	21	2.7	-1.5	0.91	0.95	1.24	NA	<0.0001
Oct.	36.00	256.32	35	3.1	-2	0.98	0.99	1.22	PA	<0.0001
Nov.	23.50	150.3	38	2.4	-1.2	0.75	0.86	1.25	NA	<0.0001
Dec.	40.00	353.35	27	3	-1.8	0.97	0.98	1.10	IS	<0.0001

Table 2: Cumulative frequency of occurrence on major food items of *B. bayad* (Sept- Dec.2019)

S/N	Food items	No. of food items	Percentage occurrence
1.	Small fishes (fries)	29	18.12%
2.	Fishes parts	40	25.0%
3.	Worms	4	2.5%
4.	Insect parts	39	24.37%
5.	Empty stomach	15	0.00%
6.	Leaf parts	10	6.25%
7.	Wheat bran	11	6.
8.	Seed particles	6	3.75%
9.	Small stones	4	2.5%
10.	Unidentified food	17	10.62%
	Total	160	100%

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SEXUAL MORPHOMETRIC DIMORPHISM OF TILAPIINE CICHLIDS FROM ASEJIRE LAKE

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ABSTRACT

The patterns and magnitude of sexual dimorphism in tilapiine cichlids from Asejire Lake (n=309) in South-west Nigeria was investigated. Size-adjusted morphometric measurements subjected to step-wise discriminant analysis was used to determine the best sex discriminators and magnitude of sexual dimorphism for each species. Swim-related traits (Pre-anal length, Pelvic fin length, and last dorsal spine) provided the greatest discrimination between sexes of tilapiine cichlids from Asejire Lake. Tilapiine cichlids from Asejire Lake showed a fair magnitude of sexual morphometric differentiation of 66.01%. The differential patterns and magnitude of sexual dimorphism expressed by tilapiine cichlids in the lake may be a reflection of the unique ecological circumstance the habitat. In essence the presence or absence of ecological opportunities for a species may be an important drive for the extent of morphological specializations between sexes.

Keywords: tilapiine cichlids, Asejire, sexual dimorphism, ecological opportunity, morphometric differentiation

Introduction

The effect of diverse environments and ecology on the magnitude of dimorphism expressed between the sexes has also been documented for a number of species due to the different nature of species interactions experienced in each habitat (Post *et al*, 1999; McPeck and Brown, 2000; Bonduriansky, 2007). Ecological reports have revealed that the extent of sexual dimorphism is constrained or regulated by the need to balance the demand for survival and the physiological cost for each sex and the population as a whole (Bonduriansky, 2007). This implies that the role of environmental factors e.g. food abundance, temperature, presence of predators and anthropogenic effects in determining the differing magnitudes of sexual dimorphism could be linked to the emergence of ecotype species i.e. a species adapted to particular environmental conditions with characteristic behavioural, structural, or physiological traits (Alfaro *et al*, 2007; Rabosky *et al*, 2007; Collar *et al*, 2009). These differences when present often manifest as morphological specializations for locomotion, nutrition, reproduction and other critical life processes of the species. As such the demands for survival experienced by each species triggers the emergence of morphological specialization of each sex (Collar *et al*, 2010) often to the advantage of the population (Lammers *et al*, 2001; Isaac, 2005; Segio *et al*, 2007).

Cichlids are notable for their phenotypic diversity, with more than 1,500 endemic species occupying tropical freshwater systems in Africa (Klingenberg *et al*, 2003). The tilapiine members of this group are well documented in their ability to harness and colonize a variety of ecological opportunities, a feature traceable to behavioural (division of labour among sexes e.g. bi-parental mouth-brooding or guarding), and morphological features (egg-spots, colour polymorphisms, and pronounced sexual dichromatism, differential diet preferences among sexes) (Fryer and Iles, 1972; Kocher, 2004; Bhatta *et al*, 2012), but with little emphasis on sexual dimorphism as a function of their environment. Hence; there is need to investigate the patterns and magnitude of sexual morphometric dimorphism in tilapiine

cichlids from Asejire Lake, in South-west Nigeria. Furthermore the relationship between habitat use and morphological variations of tilapiine cichlids living in Lake was investigated.

Materials and methods

Study Site

Asejire lake

Asejire Lake is an embankment of River Oshun. It consists of floodgates which serve the primary purpose of retaining water and has a catchment area of about 7,800 km² above the dam with a total impounded area of 2,342 ha. The lake has gross storage of 7,403 million L with an elevation of 137 m. The lake has relative humidity of 73.4-79.1%, transparency range between 0.7-1.72 m, surface water temperature of 24-31.5°C, dissolved oxygen 5.1-8.9 mg L⁻¹, pH 6.2-8.5 (Ayoade *et al.*, 2006).

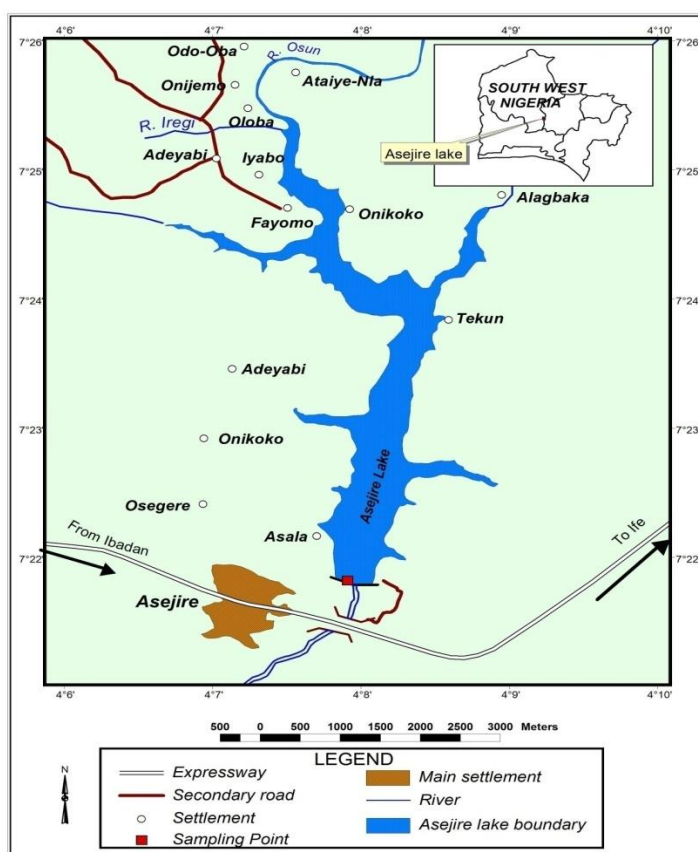


Figure 1: Map showing Asejire Lake

Sample Collection

Samples were collected between April and September, 2012. Fish sample were purchased from the fishermen at the landing sites. Gill nets and cast nets of mesh sizes 50 – 55mm were the fishing gear used. The fish samples were immediately kept in ice chest for transportation to the laboratory to avoid shrinkage.

Identification of Fish Sample

Collected fish samples were identified down to the species level using identification guide on freshwater fishes of West Africa (Paugy *et al.*, 2004) and identification guide on freshwater fishes of Nigeria (Umeh 2003). Identified species include: *Tilapia zillii*, *Tilapia guineensis*, *Tilapia mariae*, *Sarotherodon melanotheron*, *Sarotherodon galilaeus*, *Hemichromis fasciatus* and *Chromidotilapia guentheri*.

Morphometric Measurements

Twenty-nine (29) morphological measurements were made according to Neuman *et al* 2011 method on each specimen (Figure 2). Morphometric traits were taken using absolute digital calliper and all measurements were determined to the nearest millimetre. Measurements were made with the samples facing the left hand side. Body weight was measured using digital weighing balance. The morphometric characteristics measured include Total Length (TL), Standard Length (SL), Body Depth (BD), Head Length (HL), Snout Length (SnL), Eye diameter (ED) (Left And Right), Dorsal Fin Length (DFL), Anal Fin Length (AFL), Pelvic Fin Length (PvFL) (Left And Right), Pectoral Fin Length (PFL) (Left And Right), Pre orbital Length (PrOL), Caudal Peduncle Length (CPL), Caudal Peduncle Depth (CPD), Pre dorsal Length (PDL), Pre Anal Length (PAL), Lower Lip Width (LLW), Lower Jaw Width (LJW), Pelvic Distance (PD), Cheek Distance (CD), Lower Lip Length (LLP), Upper Lip Length (ULL), Pelvic Spine Length (PSL) (Left And Right), Last Dorsal Spine (LDS), Third Anal Spine (TAS).

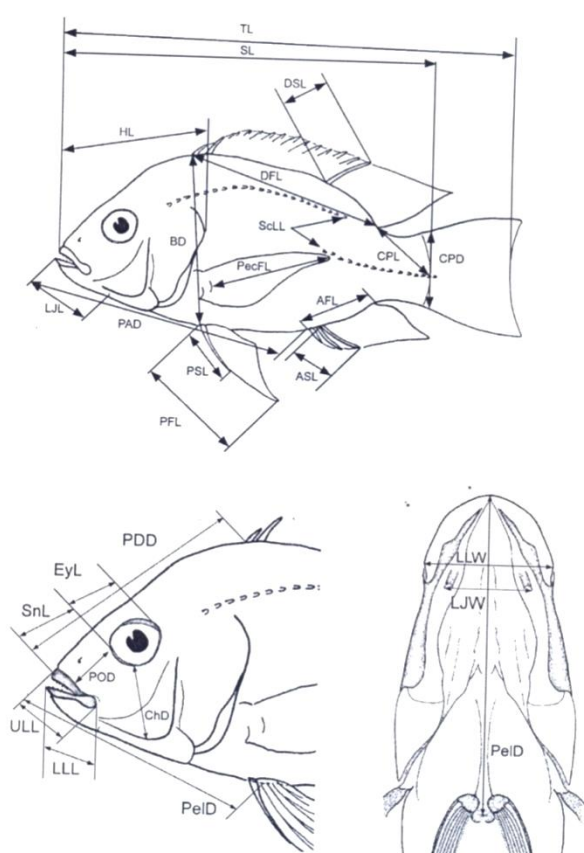


Figure 2: Map showing Morphometric variables used in study. where Total Length (TL), Standard Length (SL), Body Depth (BD), Head Length (HL), Snout Length (SnL), Eye diameter (ED) (Left And Right), Dorsal Fin Length (DFL), Anal Fin Length (AFL), Pelvic Fin Length (PvFL) (Left And Right), Pectoral Fin Length (PFL) (Left And Right), Pre orbital Length (PrOL), Caudal Peduncle Length (CPL), Caudal Peduncle Depth (CPD), Pre dorsal Length (PDL), Pre Anal Length (PAL), Lower Lip Width (LLW), Lower Jaw Width (LJW), Pelvic Distance (PD), Cheek Distance (CD), Lower Lip Length (LLP), Upper Lip Length (ULL), Pelvic Spine Length (PSL) (Left And Right), Last Dorsal Spine (LDS), Third Anal Spine (TAS).

Meristics Characteristics

Four (4) meristic characteristic were recorded according to Neuman *et al* 2011 method (Figure 2). The meristic characteristics taken were Dorsal Spine (DS), Dorsal Ray (DR), Anal Spine (AP), and Anal Ray (AR)

Statistical Analysis

All morphometric measurements of tilapiine cichlids from Asejire Lake were normalized to eliminate the allometric size effect using morphometric ratios transformation (Leonart *et al*, 2000). Morphometric data was further analyzed using step-wise discriminant analysis where the significance of the discriminant function was established using the Wilks' lambda statistic ($P < 0.05$). Larger morphometric variables between sexes were determined based on the size of the discriminant function coefficient.

The magnitude or degree of morphometric difference between males and females of each species was determined using the predicted group membership analysis of the discriminant test. The classification accuracy and cross-validation values of the predicted group membership test were representative of the percentage magnitude of sexual dimorphism for each species.

Results and Discussion

Discriminant analysis using morphometric variables for each species from the Asejire Lake showed different morphometric variables contributing to or characterizing sexual dimorphism between sexes. Fisher's discriminant function for tilapiine cichlids from Asejire Lake (table 1) gives the classification function coefficients for variables that significantly differentiated between the sexes of each species. In this result the groups i.e. male or female with the larger coefficient have the larger value for the variable differentiating them.

From table 1, pre-anal length (PAL) was significant in separating the sexes in *T. zilli* species. The males had a marginally larger coefficient (1095.53) implying that most males had a pre-anal length occupying a larger proportion of their standard length compared to the females (1079.09). For *T. guineensis* pelvic fin length (PvFL) and snout length (SnL) were the discriminating variables for the sexes. The male sexes of *T. guineensis* (165.61) had larger pelvic fin lengths than the females (143.53), while females had a longer snout length (504.36) than the males (476.61). Pelvic fin length also significantly discriminated between sexes of *S. galillaeus* with the females (817.96) having larger ones than the males (781.39). The *O. niloticus* females had larger last dorsal spine (LDS) (944.48) than the males (820.60) while males had larger pelvic fin lengths (515.28) than the females (425.65). For *H. fasciatus* males had both larger head lengths (551,050.20) and larger pelvic fin lengths (219112.79) than the females (502,026.40 and 201053.08 respectively). The pre-anal length was larger in female *T. mariae* while snout length was longer in the males (table 1).

The magnitude of sexual dimorphism was assessed across species using the predicted group membership analysis and expressed as percentage magnitude of discrimination for the sexes.

Table 1: Fisher's linear discriminant functions Asejire 201053.08

Classification Function Coefficients*		SEX	
species		Male	Female
TZ	PAL	1095.52	1079.08
	(Constant)	-417.96	-406.49
TG	PvFL	165.61	143.52
	SnL	476.60	504.36

SG	(Constant)	-113.78	-117.88
	PVFL	781.38	817.95
ON	(Constant)	-113.58	-125.12
	LDS	820.59	944.48
HF	PVFL	515.28	425.65
	(Constant)	-135.59	-131.88
TM	HL	551050.20	506026.40
	PVFL	219112.79	201053.08
	(Constant)	-151999.04	-128117.08
	PAL	1353.44	1415.47
	SnL	360.89	316.71
	(Constant)	-565.91	-600.02

*Wilks lambda <0.05

Table 2: Percentage magnitude of discrimination for male and female tilapiine species from Asejire Lake

		Predicted group membership (%)		Percentage discrimination	Magnitude of
		Male	Female	Classification accuracy (CA)	Cross-validation (CV)
TZ	Male	98.8	1.2	71.6%	70.7%
	Female	100	0.0		
TG	Male	89.8	10.2	69.0%	67.8%
	Female	75.0	25.0		
SG	Male	87.5	12.5	69.4%	69.4%
	Female	66.7	33.3		
ON	Male	90.9	9.1	83.3%	83.3%
	Female	37.5	62.5		
HF	Male	89.8	10.2	100%	25.0%
	Female	75.0	25.0		
TM	Male	89.5	10.5	84.0%	80.0%
	Female	50.0	50.0		
Mean Percentage Magnitude of Discrimination				79.55%	66.03%

The percentage magnitude of discrimination for sexes was assessed across species using the predicted group membership analysis. Table 2 showed the classification accuracy for tilapiine cichlids from Asejire Lake i.e. *T. zilli* (71.6%), *T. guineensis* (69.0%), *S. guineensis* (69.4%), *O. niloticus* (83.3%), *H. fasciatus* (100%) and *T. mariae* (84.0%). The cross-validation analysis (a more accurate statistic) showed the following trend ON (83.3%) > TM (80.0%) > TZ (70.7%) > SG (69.4%) > TG (67.8%) > HF (25.0%). From the cross-validation the mean classification accuracy for discriminating males and female tilapiine cichlids in Asejire Lake was 66.03%.

Most of the tilapiine male cichlids from Asejire lake i.e. *T. guineensis*, *O. niloticus*, *H. fasciatus* had larger pelvic fins except in *S. galilaeus* where the females had larger pelvic fins. This occurrence of bigger pelvic fins among most males may be an important adaptation for territorial defense purpose. Reports have shown that pelvic fins play a prominent role in the speed, control of body position and stability and in generating locomotor forces during propulsion and maneuvering (Lauder 2006; Lauder

and Madden, 2007) features important for territorial display. The exception in *S. galilaeus* where the females had larger pelvic fins may not be unrelated to the natural selection of the females in this species for defending mating territory (Keremah and Ndah, 2013). The elongation of these fins, as observed would increase the fin's total surface area, imparting on the sexes differing capabilities to manoeuvre. Furthermore reports have also shown that habitats impounded by dam structures favour predatory tendencies reduce the biomass of predators near the top of the food-web because smaller sized prey-fish gain passage through the dam while larger fish are blocked (Larinier, 2000). Ipinmoroti (2013) reported a high carnivore to herbivore fish ratio in Asejire lake as a reflection of the altered ecology of the habitat.

The larger pre-anal length in the male *T. zilli* may be an adaptation for propulsion while swimming or traversing fresh water terrains while the longer snout of the male *T. guineensis* may be specialized for the predating on shell fishes which are in abundance in this habitat and constitute a major part of its diet (Ipinmoroti, 2013; Shep *et al*, 2013)

The female members of the more invasive and aggressive *T. mariae* had a larger pre anal length than the males may be a swim adaptation to the altered hydrological regime of the Asejire dam, while the longer snout of the male may be an adaptation for constructing nests since they are bi-parental substrate spawners (King and Akpan, 2009). A similar interpretation may be applied for the bi-parental substrate brooder *H. fasciatus* with males having a longer head than the females. The case where the female *T. guineensis* in Asejire Lake had a longer snout than the males suggests the occurrence of role switch in which the female constructs the nests for substrate brooding. Evolutionary modeling has shown that the population scenarios like operational sex ratio i.e. partner availability, may play an important role in the plasticity of reproductive behavior (Ros *et al*, 2003). King and Akpan (2009) attributed the inter-population discrepancies in the fecundity estimates of *T. marie* as a response to several factors including differences in the quality and quantity of available trophic (energy) resources. They also inferred that different environmental condition could produce higher or lower survival opportunities for a species.

Observations from this study reveal a clear deviation from documented tendencies of this species to express sexual dimorphism. The *O. niloticus* was the only species that maintained its strong sexual dimorphic status in Lake. Sfetcu (2014) reported that *H. fasciatus* was a slightly dimorphic species. This report was confirmed in the Asejire Lake where it showed the least magnitude of sexual dimorphism (25%) compared to other tilapiine cichlids in the lake. This is the first pointer of habitat related sexual dimorphism of this species.

The land-locked nature of the Asejire habitat having only one fluvial input is characterized by a smaller surface area and an open habitat which presents lesser ecological opportunities and increased predation which also explains the emphasis on swim-related traits as features of sexual dimorphism in tilapiine cichlids from Asejire Lake. A number of studies have correlated contrasting patterns in habitat surface area to ecological opportunity and morphological divergence among populations (Aguirre 2009; Jones *et al*, 2013). Jones *et al* (2013) reported that anadromous species in habitats with sufficient littoral habitat harnessed food resources from both littoral and pelagic sources while landlocked anadromous species were almost exclusively dependent on pelagic prey and such ecological scenarios have been implicated in populations expressing different phenotypes (McPhee *et al*, 2012). Populations in lakes with relatively more littoral habitat are often deep bodied with larger heads and deeper caudal regions (Walker 1997). This morphotype is adapted for increased burst of speed and better steering of the individual and useful for exploring structurally complex environments for forage (Walker 1997; Langerhans 2009). Conversely populations in lakes with relatively more pelagic habitat show a more fusiform body shape characterized by shallower bodies, smaller heads, and a slender caudal region.

These more streamlined features enhance steady swimming ability and make for more efficient use of open habitats (Jones *et al*, 2013).

Conclusion

The study clearly revealed sexual dimorphism in the cichlids of Asejire Lake, although, magnitude of sexual morphometric dimorphism differ from species to species and the sexual dimorphism recorded in this study are strongly habitat-dependent and determined by the presence or absence of functional constraints imposed on each species by the habitat.

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STAGES OF EGG DEVELOPMENT OF *MACROBRACHIUM FELICINUM* (HOLTHUIS, 1949) (CRUSTACEA: DECAPODA: NATANTIA) IN THE LOWER RIVER BENUE, MAKURDI, NIGERIA

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ABSTRACT

Stages of egg development of *Macrobrachium felicinum* were investigated in the Lower River Benue in August 2020, when ovigerous females were noticed in the catches of fishermen. Two hundred (200) specimens of ovigerous females were collected from the fishermen using set traps and traditional gear known as “Ahina”. The specimens were transported in icebox containing water to the laboratory for further studies. The prawns were identified to species level. Egg development was characterized into five stages based on colour of egg mass. Most of the eggs (31.2%) were in stage 4, followed by Stage 3 which had 26.8%, then stage 1 with 24.8%, then stage 2 with 12.3%. Stage 5 had the least number of ovigerous females (4.9%). The presence of all the stages of egg development in the specimens projects River Benue as a likely place for both breeding and spawning of *M. felicinum* which is recommended as a good candidates for aquaculture in Nigeria.

Key words: Niger River prawn, Lower River Benue, Egg Development, *Macrobrachium felicinum*

INTRODUCTION

Prawn cultivation is an important industry that generates billions of US dollars in export annually (Flegel 2012). It contributes significantly to poverty alleviation. The average income per capita of a prawn farm household member was seven times higher than the national average. It generates employment in rural areas both from the hiring of farm workers and by the self-employment of household members (Pongthanapanich et.al., 2019). However, Countries in East and Southeast Asia (83.4% of production) and Latin America (16.3%) account for the major share of prawn production (Emerenciano et. al.,2022).

Aquaculture production from Africa is overwhelmingly dominated by finfishes (99.3%), with only a small fraction from shellfish such as prawn and shrimp (0.5%) and marine molluscs (0.2%) (FAO, 2012). This is the situation in Nigeria. Although the aquaculture sector in Nigeria has been growing, the prawn and shrimp sub-sector has shown a worrying slowdown. Aquaculture production in Nigeria increased from 25 718 tonnes in 2000 to 261 711 tonnes in 2020 with finfish having a share of 92.6% while shellfish production was 7.4% (FAO, 2022).

Nigeria is still struggling with production capacity of 12, 000 tonnes of shellfish annually (the Nation, 2021, Obetta *et al.*, 2022). This is due to inadequate information on biology and farming technology of prawn. Among freshwater prawns, *Macrobrachium rosenbergii* has been successful in commercial farming because its biology and farming technology are well known compared to other species (Valenti, 1990). In order to take advantage of the ecological and economic benefits of prawn farming in Nigeria, there is need to intensify research on its reproductive biology and farming techniques.

In West Africa, *Macrobrachium* species can be found throughout the region and play an important role in domestic fishery resources (Etim & Sankare, 1998; Nwosu & Wolfi, 2006). *Macrobrachium felicinum* (Plate 1) has been reported to occupy the Northern part of Nigeria including River Benue (Obande and Kusemiju, 2006; Ayoola *et. al.*, 2009).

Some research carried out on sex population structure and other aspects of biology of *Macrobrachium* species include: Marioghae (1982), Powell (1982), Nwosu and Wolfi (2006), Bahuguna (2003) and Ukagwu (2020). Little or no work has been reported on egg development of *M. felicinum* This study aims to identify the various stages of egg development of *M. felicinum* so as to provide basic guide for further studies when dealing with ovigerous prawns of this or closely related species.

MATERIALS AND METHODS

Study areas

The prawns were collected from River Benue, located in Makurdi (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. 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 area of Lower River Benue is about 129,000 hectares with as much as 25m difference between high and low water levels.

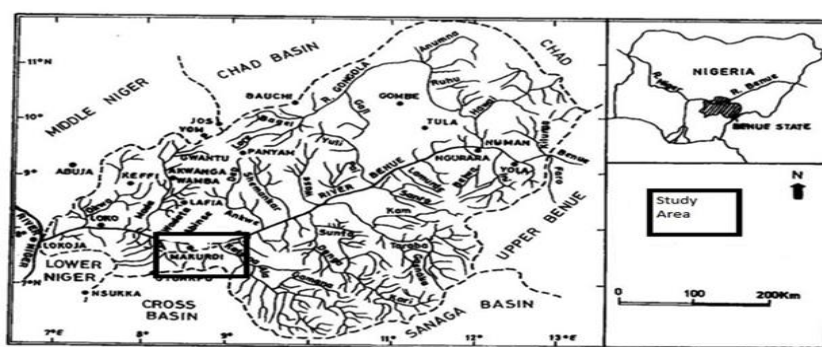


Fig. 1: Map of Lower River Benue showing Makurdi, the sampling site. Source: Wikipedia.com (2015)

Prawn collection, species identification and determination of stages of egg development

Prawn specimens were collected from fishermen using unbaited local non-return set trap which was dropped in a marked position for ease of retrieval. Another trap used was leaves called “Ahina” in local (Tiv) language. The leaves were tied to sticks in the shallow part of the river and left for two or more days after which the leaves were collected in baskets to check for prawns. The collected prawns were transported in iced box containing water to the laboratory for further studies. The prawns were identified to species level, using keys by Powell (1982). Stages of egg development were characterized based on the colour of egg mass according to Anetekhai (1990).

Results and Discussion

Stages of egg

All the five stages of egg development were encountered in the samples (plate 1). Stage 1 is shown in A. it represents newly spawned eggs with orange colouration. Stage 2 which is B shows changes in coloration from orange to light green; eggs in stage 3 as in C are Dark green in colour; brown colour was observed for eggs in stage 4 as in D; and gray was observed for eggs in stage 5, represented in E, about to hatch. Most of the eggs (31.2%) were in stage 4, followed by Stage 3 which had 26.8%, then stage 1 with 24.8%, followed by stage 2 with 12.3%. Stage 5 had the least number of ovigerous females (4.9%) (Table 1).

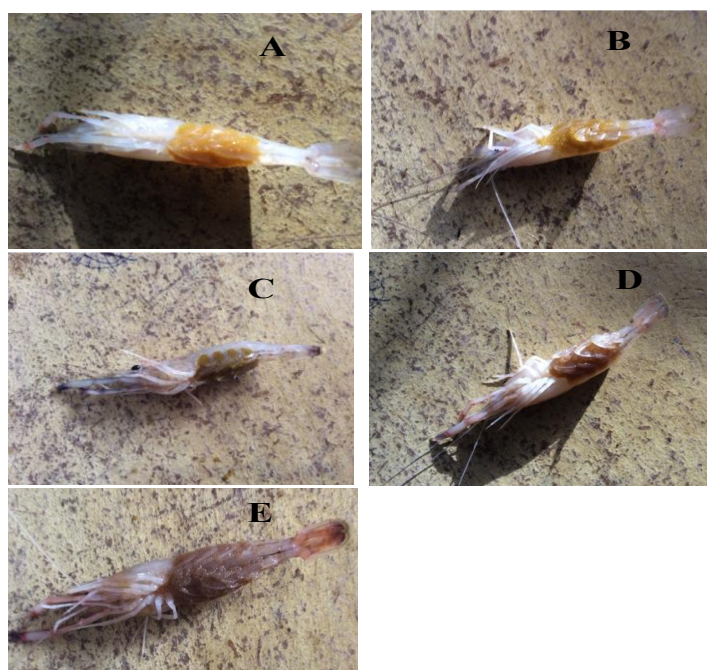


Plate 1: Stages of Embryonic Development, Based on Egg Colour of *M. felicinum*. A= Stage 1 (Orange coloured eggs), B= Stage 2 (Light green-coloured eggs), C= Stage 3 (Dark green-coloured eggs), D= Stage 4 (Brown coloured eggs) and E=Stage 5 (Gray coloured eggs)

Table 1: Stages of Egg Development of *M. felicinum* in River Benue, August, 2020 to December, 2018

Stage of Egg Development	Percentage (%)
Stage 1	31.2
Stage 2	12.3
Stage 3	26.8
Stage 4	31.2
Stage 5	4.9

All the stages of egg development of *M. felicinum* were represented in the samples. This indicates that River Benue is likely a breeding and spawning ground for *M. felicinum*. Egg colour ranges from orange colour to gray and oval in shape before hatching. This corresponds with the findings of Habashy *et al.* (2012) on the morphological studies of the embryonic development of *M. rosenbergii*, in which the eggs were slightly elliptical in shape, initially bright orange to yellow in colour which gradually changed to deep brown and gray a few days before hatching. In the fertilized eggs of *M. idella* *Idella* and *M. gangeticum*, eggs were opaque, greenish round and oval shape and, as development progresses, its greenish colour changes into light green, brownish-yellow and finally to dull whitish in colour when it is about to hatch (Kanaujiya, 2003). Using egg colour, classification was also made as: immature, developing and ripe (Anetekhai, 1990). The immature eggs were orange in colour, the developing eggs were greenish in colour and the ripe eggs were dark gray in colour with two eye spots referred to as 'eye' larval eggs (Xavier, 1997). These egg colour changes were attributed to the absorption of the yellow yolk and development of dark pigment in the eyes (Vijayakumar, 1992 and Veera, 1994).

CONCLUSION

The fact that all the stages of egg development were observed in the samples leads to a conclusion that Makurdi is likely a breeding and spawning ground for this species. This has also inspired the thought that this species is likely a complete freshwater prawn.

RECOMMENDATION

It is recommended as an excellent candidate for aquaculture, since its seeds are readily available in the wild. Makurdi is recommended for collection of its broodstock, when water level is high (from July to August), for commercial production of post-larvae in captivity for the progress of prawn culture in Nigeria.

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FISH SPECIES DIVERSITY AND ABUNDANCE OF LAKE NJOBOLIYO, YOLA-SOUTH LOCAL GOVERNMENT AREA, ADAMAWA STATE, NIGERIA

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ABSTRACT

The study of fish diversity and abundance in Lake Njoboliyo was conducted for the period of six month (from December 2018 to May 2019). The specimens were collected monthly with the assistance of artisanal fishermen at the landing site using various fishing gear like gill net, cast net, drag net, hook and line, traps etc. A total of 5067 fish were sampled. Fifty six (56) species representing (17) families were identified. The family *Mochokidae*, has the highest species with eight (8) species representing the family followed by families *Momyridae* and *Alestidae* has seven (7) and six (6) species respectively, *Clariidae* and *Bagridae* with five (5) species each. The remaining families (*Latidae*, *Osteoglossidae*, *Malapteruridae*, *Protoptaridae*, *Gymnarchidae*, *Siluridae*, *Polypteridae*, *Distichodontidae*, *Channidae*, *Cichlidae*, *Cyprinidae*, *Citharinidae*

) had between one (1), two (2) and four (4) species representing each of the families. *Oreochromis niloticus* which belong to Cichlidae family has the highest percentage composition (9.57%) and *Polypterus senegalus* of the family polypteridae has the least percentage composition (0.12%). The relative abundance, month of March, 2019 has the highest relative abundance of 1035 fish while the month of May, 2019 has the lowest relative abundance of 721 fish.

Key: Fish species, Diversity, Abundance, and Lake Njoboliyo

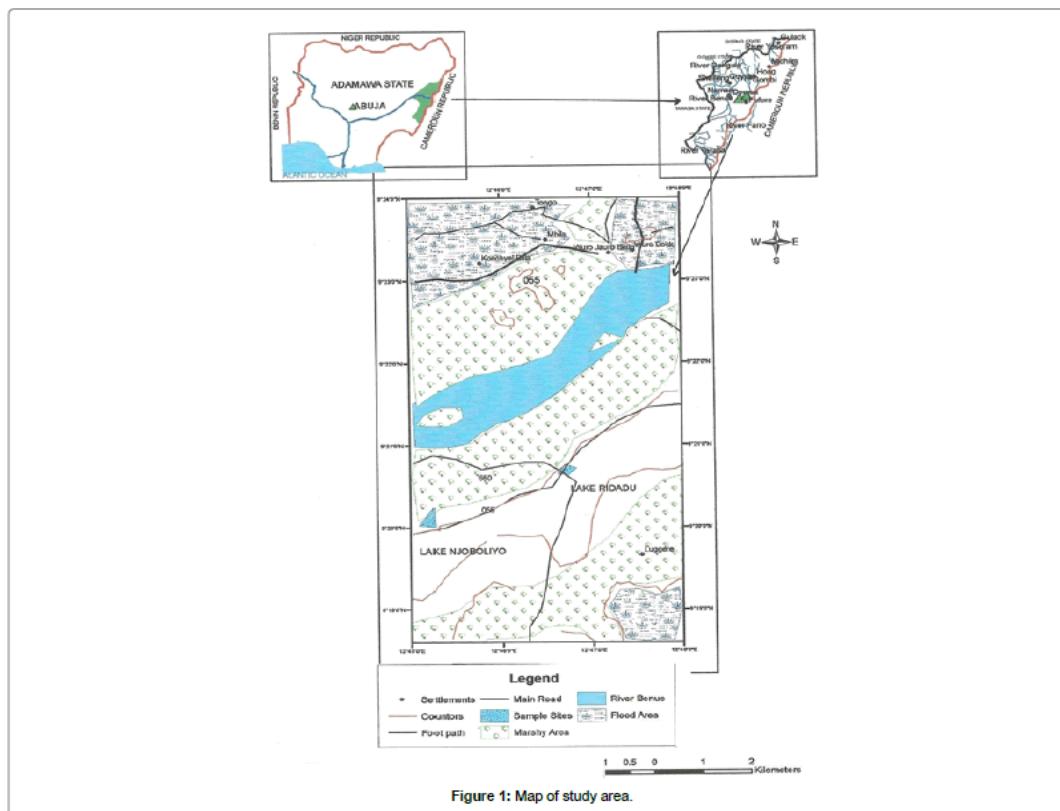
INTRODUCTION

Fishes are the most numerous species of the vertebrate animals and about 27, 650 species of fishes are known and approximately 11, 300 species or 41% of all fishes species live in fresh water (Zira *et al.*, 2017). Distribution and abundance are important variables of fish population dynamics studies that will help in evaluating the effect of fishing on a fishery as a basis of fishery management decisions (Adeyemi *et al.*, 2010). Throughout Africa and Nigeria in particular, the occurrence of a large number of inland or freshwater Reservoirs, Lakes, Rivers and other aquatic habitats such as swamps and flood plains, of different sizes and forms, and containing a wide variety of fish populations, have provided mankind with the opportunity to exploit fish for food, income and livelihoods in general for many centuries (Neiland, 2005). The fish resource in Nigeria, apart from being a major source of cheap and quality animal protein for rural dwellers and raw materials for some industrial activities as well as recreational purposes (Zira *et al.*, 2017). Major linear to fish biodiversity have been identified as over exploitation, followed identification of habitat destruction, inversion of exotic species and pollution. The study of fish diversity and abundance is becoming an important issue as such lack of update information on fish species diversity and abundance becomes a substantial problem to fish demand to population.

MATERIALS AND METHODS

Study Area

Njoboliyo Lake lies within the latitude 9.12 to 16.15N and longitude 12.28 to 12.43E. The Lake is found in eastern part of Yola south Local Government. The major ethnic groups of the area are Bwatiye, Fulbe, Mbula and few migrant fishers that comprises Hausa, Jukum and Agatu (Figure 1). Some of this migrant fishers has over the years become indigen to that area. The Lake is wet flooded plain lake found adjacent to river Benue, this Lake has it course from river Nafari and Chigari as inlet and empties into river Benue. The Lake is perennial, Chigari and Nafari take their course from the Mandara highland on entering Nigeria. They meanders along their ways with continues deposition of alluvias's and sands, leading to formation of many oxbow lakes within the geographical location of the Benue (Adebayo and Tukur 1999).



Fish Sampling

The study was conducted for the period of six months and the samples was randomly taken from the catches of local fishermen at the landing site and the sample is counted and recorded.

Species Identification

The identification of fish species was done by using Field Guide to Nigeria Freshwater Fisheries by Babatunde and Raji (1998).

Data Analysis

The data was collected from landing site (primary source of data) with the assistant of artisanal fishermen were analyzed by using simple statistical percentage, the computer analysis was carried out using statistical package for social science (SPSS).

RESULTS AND DISCUSSION

The percentage composition of the species identified at Lake Njoboliyo is shown on Table 1. The table reveals that, *Oreochromis niloticus*, *Tillapia zilli*, *Labeo couble* and *Oreochromis aureus* had 9.57%, 8.19%, 4.40 and 4.32% of the total fish species identified. *Clarias gariepinus*, *Alestes dentex*, *Heterobranchus longifilis* and *Mormyrus rume* had 3.45%, 3.41% and 3.36% respectively. The remaining fish species had percentage composition between 0.12% and 3.26% . Table 2 present the relative abundance and distribution of various fish species identified at Lake Njoboliyo. The result reveals that, the Lake had its high relative abundance in the months of March and February, 2019, with relative abundance of 1035 and 927 respectively. The least relative abundance was in the months of January and May, 2019 with relative abundance ranged between 721 and 761 respectively. The species identified during the months of December, 2018 to May, 2019 revealed that *oreochromis, niloticus* was the highest with (485), followed by *Tilapia, zilli* (415) while the lowest were *Hemichromis bimaclatus* and *Polypterus senegalus* with (5) and (6) respectively.

The fish species in Lake Njoboliyo were (56) species representing (17) families appears to be richer than those of Zira *et al.* (2017) in kiri Reservoir, Shelleng , Adamawa state, Nigeria. who reported 47 species and 15 families, 26 fish species reported by Ja'afaru and Abubakar (2015) in DadinKowa Dam,

Gombe State, Nigeria, 31 reported by Dan-Kishiya (1991) and 36 species reported by Abubakar, (2006) in lake Geriyo respectively, but its lower in species richness than 85 fish species by Sydenham (1997) in Ogun river, 81 species by Odiko *et al.* (2010) in river Ovia, Edo state, and 98 fish species by Nwadiora (1989) in Oguta lake all in southern Nigeria.

In terms of the relative abundance of 56 species identified, *Oreochromis niloticus* of the family Cichlidae were the most dominant species constituting 9.57% of the total catch of (485), this result agreed with the work of Dan-Kishiya *et al.* (2012) who reported that fish family Cichlidae was the most dominated species in lower Usuma Reservoir and Abubakar (2006) who reported *O. niloticus* as the most abundant species in lake Geriyo. Abiodun and Miller (2005) also reported *O. niloticus* and *Sarotherodon* as the most abundant species in Lake Geriyo. Adeyemi *et al.* (2010) also reported *O. niloticus* as the most abundant in Gbedikere Lake, Bassa, Kogi State. The dominance of the cichlids could be attributed to their prolific breeding habit. The Cichlids are found to breed about three to four times in the year (Bankole *et al.*, 1994).

High catches and species identified were observed during the period of the study in dry season (i.e March, 2019), this finding agrees with that of Alfred-Ochiya (1997) in Kolo creek, Allison *et al.* (1997) in Elechi creek, both in River State and Meye and Ikomi (2008) in Urie creek at Igbide in Delta state who reported high catches and species identified in dry season. The reason for the high catches may be attributed to the ability of the fishers during the dry season, to access further parts of the fishing grounds because of decreased water depth and increased available space which are otherwise inaccessible during the wet season.

Conclusion

The result revealed that a total of 5065 fish species were sampled, (56) species representing (17) families identified in Lake Njoboliyo. *Oreochromis niloticus* is the most abundant species of the family Cichlidae. High catches and species identified were observed during the period of the study in dry season.

Table 1: Percentage Composition of Fish species identified at Lake Njoboliyo

Fish species	Number Identified	Percentage (%)
<i>Clarias gariepinus</i>	175	3.45
<i>Clarias anguillaris</i>	165	3.26
<i>Clarias lazera</i>	74	1.46
<i>Heterobranchus longifilis</i>	173	3.41
<i>Heterobranchus Bidosalis</i>	151	2.98
<i>Oreochromis niloticus</i>	485	9.57
<i>Oreochromis aureus</i>	219	4.32
<i>Tillapia zilli</i>	415	8.19
<i>Hemichromis bimaculatus</i>	5	0.10
<i>Clarotes laticeps</i>	95	1.87
<i>Bargus bayad macropterus</i>	94	1.86
<i>Bargus docmack</i>	108	2.13
<i>Auchenoglanis biskutatus</i>	54	1.07
<i>Auchenoglanis accidentalis</i>	36	0.71
<i>Mormyrus rume</i>	170	3.36
<i>Mormyrus macrophthalmus</i>	94	1.86
<i>Mormyrus Tapirus</i>	60	1.18
<i>Hyperopisus bebe</i>	103	2.03
<i>Petrocephalus bane</i>	54	1.07
<i>Petrocephalus bove!</i>	25	0.49
<i>Petrocephalus ansorgii</i>	72	1.42
<i>Schilbe intermedius</i>	26	0.51
<i>Schilbeidae buffei</i>	25	0.49
<i>Alestes dentex</i>	175	3.45

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<i>Alestes macrophthlmus</i>	56	1.10
<i>Alestes baremoze</i>	115	2.27
<i>Hydrocynus vittatus</i>	26	0.51
<i>Hydrocynus forskalii</i>	118	2.33
<i>Hydrocynus beris</i>	87	1.72
<i>Labeo couble</i>	223	4.40
<i>Labeo seneglensis</i>	129	2.55
<i>Raiamas seneglensis</i>	19	0.37
<i>Raiamas negriensis</i>	17	0.36
<i>Synodontis clarias</i>	102	2.01
<i>Synodontis nigrita</i>	76	1.50
<i>Synodontis schall</i>	69	1.36
<i>Synodontis budgeft</i>	23	0.45
<i>Synodontis vermiculata</i>	17	0.36
<i>Synodontis sorex</i>	65	1.28
<i>Synodontis coureteti</i>	22	0.43
<i>Synodontis batensoda</i>	88	1.74
<i>Gymnarchus niloticus</i>	21	0.41
<i>Polypterus bichir bichir</i>	40	0.80
<i>polypterus senegalus</i>	6	0.12
<i>protepterus annectens</i>	112	2.21
<i>Distichodus engycephalus</i>	81	1.60
<i>Distichodus rostratus</i>	76	1.50
<i>Heterotis niloticus</i>	56	1.10
<i>Cithadium ansorgii</i>	21	0.41
<i>Cithadium disticho</i>	107	2.11
<i>Cithadium latus</i>	29	0.57
<i>Cithadium citharus</i>	62	1.22
<i>Malapterurus electricus</i>	21	0.41
<i>Parachana</i>	47	0.93
<i>parachana Africana</i>	27	0.53
<i>Lates niloticus</i>	56	1.10
TOTAL	5067	99.99 %

Table 2: Relative Abundance and Distribution Fish species identified at Lake Njoboliyo

FISH SPECIES	MONTHLY (DEC,2018 TO MAY, 2019)						
	DEC.	JAN.	FEB.	MAR.	APR	MAY	TOTAL
<i>Clarias gariepinus</i>	45	35	42	30	16	7	175
<i>Clarias anguillaris</i>	39	37	42	30	9	8	165
<i>Clarias lazera</i>	16	16	20	14	6	2	74
<i>Heterobranchus longifilis</i>	36	45	40	32	14	6	173
<i>Heterobranchus Bidosalis</i>	38	50	31	24	8	-	151
<i>Oreochromis niloticus</i>	50	73	125	80	75	82	485
<i>Oreochromis aureus</i>	16	22	39	42	60	40	219
<i>Tillapia zilli</i>	62	88	57	75	80	53	415
<i>Hemichromis Bimadatus</i>	-	2	-	1	-	2	5

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<i>Clarotes laticep</i>	22	11	9	16	22	15	95
<i>Bargus bayad</i>	13	9	16	24	14	18	94
<i>macropterus</i>							
<i>Bargus docmack</i>	24	16	13	19	20	16	108
<i>Auchenoglanis biskutatus</i>	4	7	11	10	13	9	54
<i>Auchenoglanis</i>	14	6	3	2	7	4	36
<i>accidentalis</i>							
<i>Mormyrus rume</i>	18	14	32	48	40	18	170
<i>Mormyrus</i>	11	16	13	32	10	12	94
<i>macropteralinus</i>							
<i>Mormyrus Tapirus</i>	4	3	6	28	9	10	60
<i>Hyperopisu bebe</i>	14	18	21	10	21	19	103
<i>Petrocephalus bane</i>	11	20	7	6	8	2	54
<i>Petrocephalu sbove!</i>	2	6		- 12	5	-	25
<i>Petrocephalus ansogiiS</i>	16	13	8	10	16	9	72
<i>schilbe inbtermedius</i>	2	5		- 9	4	6	26
<i>schilbeidae buffei</i>	5	4	7	2	4	3	25
<i>Alestes dentex</i>	22	28	42	35	28	20	175
<i>Alestes macrophthlmus</i>	10	5	11	4	10	16	56
<i>Alestes baremoze</i>	19	25	28	16	9	18	115
<i>Alestes leuciscus</i>	4		6	8	5	3	26
		-					
<i>Hydrocynus forskalii</i>	20	25	13	8	32	20	118
<i>Hydrocynus beris</i>	16	14	18	10	11	18	87
<i>labeo couble</i>	38	20	41	50	44	30	223
<i>labeo seneglensis</i>	22	11	26	52	10	8	129
<i>raiamas seneglensis</i>		-	4	12	3	-	19
		-					
<i>raiamas negrienesis</i>	4		2	6	2	3	17
		-					
<i>Synodontis clarias</i>	11	7	18	14	22	30	102
<i>Synodontis nigrita</i>	10	9	11	16	12	18	76
<i>Synodontis sorex</i>	6	12	10	20	3	14	65
<i>Synodontis coureteti</i>		1	4	12	-	5	22
	-						
<i>Synodontis batensoda</i>	9	13	22	16	17	11	88
<i>Gymnachus niloticus</i>	2	1	-	4	8	6	21
<i>Polypterus bichir bichir</i>	4	3	-	18	13	2	40
<i>polypterus senegalus</i>	-	1	-	-	2	3	6
<i>protepterus annectens</i>	2	5	10	16	35	44	112

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<i>Distichodus brevipinus</i>	14	10	13	14	12	18	81
<i>Distichodus engycephalus</i>	7	2	14	16	18	19	76
<i>Heterotis niloticus</i>	3	9	6	10	10	18	56
<i>Cithadium ansorgii</i>	1		4	3	5	8	21
<i>Cithadium disticho</i>	15	5	19	36	15	17	107
<i>Cithadium latus</i>	2	9	8	2	4	4	29
<i>Cithadium citharus</i>	5	4	13	19	21	-	62
<i>malapterurus electricus</i>	8		1	4	6	2	21
<i>parachana obscura</i>	2		6	17	14	8	47
<i>parachana africana</i>	9	3	8	5	2	-	27
<i>lates niloticus</i>	18		4	16	6	12	56
<i>Synodontis membranace</i>	15	10	12	17	13	2	69
<i>Synodontis budgeft</i>	4	6	7	2	4	-	23
<i>Synodontis vermiculata</i>	2	7	4	1	-	3	17
	766	761	927	1035	857	721	5067

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FISH BREEDING AND GENETICS

COMPARATIVE STUDY ON THE REPRODUCTIVE INDICES AND GROWTH PERFORMANCE OF CLARIAS GARIEPINUS FROM THREE LOCAL GOVERNMENT AREAS IN ADAMAWA STATE

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ABSTRACT

Studies of intra-specific hybridization between *C. gariepinus* from Adamawa in the North-East Nigeria was carried out, under hatchery conditions, with the aim of estimating their aquaculture potential. The broodstock of *C. gariepinus* were procured from Modibbo Adama University of Technology Yola research farm, Fufore and Malkohi, Adamawa State. The result showed that in all the nine genetic crosses, Malkohi had percentage fertilization of (91%) RS (85.0%), FF and MK (80) hatchability RS (70%), FF (70%) and MK (80%) then survival RS (90.0%), FF (80%) and MK (70%). Malkohi and Research farm were significantly ($P < 0.05$) higher. Progeny from Malkohi gave the best result. The breeding potentials of *Clarias gariepinus* strain from Malkohi and Research farm were better when crossed breed. The milt volume were RS (1.0ml), FF (2.8ml) and MK (3.0ml), sperm motility (total motile sperm) were RS (65), FF (60) and MK (75) then, the average testes length of both L-R lobe were RS (4.8cm), FF (9.9cm) and MK (6.5cm). The fingerlings from Malkohi and Fufore had the best growth performance. Farmers could be encouraged to culture them for profit maximization.

Keywords Comparative study; Reproductive indices; Growth performance and *C. gariepinus*

INTRODUCTION

Fish production through hybridization is an age long practice in Africa. Hybridization in African catfishes *Clarias gariepinus*, *Clarias anguillaris*, *Heterobranchus bidorsalis* and *Heterobranchus longifilis* has been in practice in Africa (Adah *et al.*, 2014). Hybridization has been used to improve fish, increase growth rate, manipulate fish sex, production of sterile fish, and improve flesh quality, increase semen volume, increase disease resistance, and environmental tolerance (Bartley *et al.*, (2000) Hybridization is used to produce offspring that performs better than both parental species (positive heterosis). Hybridization is the generation of a new form of plant or animal either naturally or by human intervention through combining the genes of two different species or subspecies. Fish hybridization is when two different species, genera or families are crossed, crossing of the first filial generation, backcrossed or out crossed to give the hybrid of desired qualities. Fish hybridization is an essential genetic technique that removes undesirable characteristics while retaining the desirable ones.

Study Area

The research was conducted in the Department of Fisheries teaching and research farm, Modibbo Adama University Yola, Adamawa State, Nigeria, which is located within Guinea Savanna zone, lies between Latitude 9°27'18N and longitude 12°28'15.38"E.

Experimental Design

The experimental design was a complete randomized design. The three different strains (male and female obtained from Malkohi, Fufore and Fisheries Research Farm. The research were carried out in nine treatments and in triplicates in each treatments (9x3). Twenty seven bowls of 25ltrs were used.

Experimental Setup

Twenty seven (27) plastic bowls of 25litres volume were used. The research were carried out in nine treatments and in triplicates in each treatments (9x3). Each treatment was in triplicate and twenty (20) fingerlings were stocked in each bowls.

Brood stocks Sourcing and Management

Two gravid male and female *C. gariepinus* weighing between 900g-2kg were obtained from Malkohi, Yola Adamawa State and another two gravid male and female *C. gariepinus* were also obtained from Fufore and Fisheries Research Farm. The Broodstocks were transported, using 50L capacity jerry cans to the Department of Fisheries Teaching and Research Farm, Modibbo Adama University Technology, Yola, where the broodstocks were acclimatized for one week.

Induced Breeding

The female broodstocks were used for breeding was tested by holding the fish in a head-up vertical position and a slight pressure was applied by pressing its abdomen with a thumb from the pectoral fin towards the genital papilla after which eggs ran out freely Olanrewaju *et al.*, (2009). The selected broodstock were kept separately in different tanks without feeding them, after they were injected with 0.5 ml Ovulin per kg live weight (Oyeleye and Omitogun, 2007) and then left for 10-12 hours latency period as a post ovulatory maturation period and to ensure high hatching rates and low proportion of deformed larvae, after the eggs have been stripped and the milt collected.

Mode of Administration of Hormone

The hormone was administered intramuscularly above the lateral line and below the anterior end of the dorsal fin. After the injection, the site of injection was pressed slightly before removing the needle to prevent the hormone from running out. The injected brood stocks were kept separately in plastic containers with about 10 liters of water each for the period of stipulated latency period.

Collection of Eggs and Milt

The collection of eggs and milt were done, the eggs were collected from each ovulated female through stripping by gently pressing the abdomen of the fish. The eggs were collected into clean bowls labelled according to the treatments. Milt was obtained by sacrificing the males. Each male was dissected carefully and their milt sac obtained. The both lobes of the testes were weighed with digital weighing machine.

Artificial Fertilization and Incubation

Dry method of fertilization was used where the milt obtained from the male fishes was squeezed onto the stripped eggs obtained from the females accordingly and stirred gently and thoroughly using plastic spoon for about 1-2 minutes to allow contact and adequate fertilization (Megbowon *et al.*, 2013), after which normal saline was added before spreading the eggs on the spawning nets in the incubation units for incubation.

Experimental Crosses

Experimental Crosses of *Clarias gariepinus* of different strains

	MK♀	FF♀	RS♀
MK♂	MK♂xMK♀	MK♂xFF♀	MK♂xRS♀
FF♂	FF♂xMK♀	FF♂xFF♀	FF♂xRS♀
RS♂	RS♂xMK♀	RS♂xFF♀	RS♂xRS♀

Bold crosses are the purebreds.

Where:MK *C. gariepinus* strains from Malkohi;FF *C. gariepinus* strains from Fufore;RS *C. gariepinus* strains from Fisheries Research Farm

Fecundity

Gravimetric method was used to estimate the number of eggs spawned. A quantity of eggs stripped was weighed using weighing sensor and reading was taken which was used for further estimate of all the stripped eggs. Sub-sample was randomly taken, washed with saline water, counted and then weighed. Fecundity was calculated as follows:- $F = \frac{nG}{g}$ Where: F = fecundity;n = No. eggs in the subsample;G = Total weight of the ovaries;g = weight of the subsample in the same unit; Armando *et al.* (2009)

Percentage Fertilization Determination.

Twenty eggs from each treatment were put into one liter capacity bowls for some hours, the fertilized eggs was differentiated from the unfertilized eggs by the presence of “eyes spot” the swollen nature of fertilized eggs and also the grayish colour of fertilized eggs. The unfertilized eggs appeared opaque, pale and white. The fertilization rate was calculated as reported by (Ochokwu *et al.*, 2016). % Fertilization = Number of fertilized eggs/total number of eggs x 100.

Data Analysis:Data were collected and analyzed using SPSS v. 22, and was subjected to one way analysis of variance (ANOVA), at 95% level of confidence and means was separated using Least Significant Difference (LSD).

Result and Discussion

The sperm quality of the parent stocks from MK, FF and RS (Table 1) showed that the weight of fish were 1kg (MK), 2.5kg (FF) and 1.2kg (RS). Their lengths were 55cm (MK), 70cm (FF) and 45cm (RS) respectively. The weight of the right lobe were 1.95(MK), 1.58(FF) and 1.61(RS). The weight of left lobe were 7.0(MK), 10.3(FF) and 5.1(RS) respectively. Their milt volume were 3.0(MK), 2.5(FF) and 1.0(RS). The sperm count experiment was carried out in the laboratory at German Medical Center Adamawa State. The sperm count were counted in 1ml per each sample 716.8 (MK), 463.8(FF) and 934.6(RS) respectively. The sperm motility were evaluated on active cells 35(MK), 25(FF), 40(RS) and sluggish cells 40(MK), 35(FF), 25(RS) and immotile cells 35(MK), 45(FF) and 20(RS). The number of Eggs in 1g of the parent stocks from MK, FF and RS (Table 2) showed that the weight of the experimental fishes were 2000g (MK), 2800g (FF) and 900g (RS) respectively. The length of fish were measured in cm 63.0(MK), 70.0(FF) and 46.5(RS). While the weight of the eggs were 144.26g (MK), 357.43g (FF) and 167.53g (RS) respectively. The No. of Eggs in 1g were 762(MK), 795(FF) and 753(RS) respectively. The total number of eggs were 109,926(MK), 248,156(FF) and 226,150(RS). The female fish from Malkohi (MK) has the highest number of eggs follow by others respectively. While, the eggs diameter were measured 1.0(MK), 0.9(FF) and 0.7(RS). The %fertilization were 70% (MK)

Table 1: Sperm Quality of *Clarias gariepinus* from different Locations

Parameter	MK	FF	RS
Weight of Fish(g)	1000	2500	1200
Length of Fish(cm)	55	70	45
Weight of Right Lobe(g)	1.95	1.58	1.61
Weight of Left Lobe(g)	1.90	1.34	1.66
Length of Right Lobe(cm)	6.0	9.5	4.5
Length of Left Lobe(cm)	7.0	10.3	5.1
Milt Volume(ml)	3.0	2.5	1.0
Sperm Count($\times 10^6$ /ml)	716.8	463.8	934.6
Sperm Motility (%)			
Active Cells	35	25	40
Sluggish Cells	40	35	25
Immotile Cells	35	45	20
Total Motile Sperm(TMS)	75	60	65

Key:♂=Male Broodstocks;MK=Malkohi;FF=Fufore;RS=Research Farm

Table 2: Mean Values of Eggs Quality of *Clarias gariepinus* from three Local Government Areas

Parameter	MK	FF	RS
Weight of Fish(g)	2000	2800	900
Length of Fish(cm)	63.0	70.0	46.5
Weight of Eggs(g)	144.26	357.43	167.53
No. of Eggs in 1g	762	795	753
Total No. of Eggs	109,926	248,156	226,150
Egg Diameter (mm)	1.0	0.9	0.7
% Fertilization	70	90	50
% Hatchability	90	70	80
GSI (%)	7.21	12.765	18.614

Key:♀=Female Broodstocks;MK=Malkohi;FF=Fufore;RS=Research Farm

The percentage fertilization, hatchability and survival (Table 3) showed that the RSXMK had 91, while follow by others respectively. The percentage hatchability of MKXFF, MKXRS and RSXMK had 80% which has higher hatchability follow by other treatments. From the table below MKXMK, MKXRS and RSXMK had 80% and above and has the highest survival rate and follow by others treatments.

The parent stocks (Table 3) showed that the MKXMK, RSXRS had 80% fertilization, 70% hatchability and 90% Survival, was the highest, while, the FFXFF had the lowest values.

The hybrid reciprocal of RSXMK, MKXFF, MKXRS and FFXRS had 91%, 85%, 84% and 85% fertilization, 80%, 80%, 80% and 70% hatchability, also, 83%, 40%, 85% and 60% survival. From the result shown that RSXMK has the highest values follow by others.

Table 3: Percentage fertilization, hatchability and survival of *C. gariepinus* strains and their hybrids reciprocal.

Genetic Crosses	% Fertilization	% Hatchability	% Survival
MKXMK	80	70	90
FFXFF	55	40	60
RSXRS	80	70	60
MKXFF	85	80	40
MKXRS	84	80	85
FFXMK	60	55	50
FFXRS	85	70	60
RSXMK	91	80	83
RSXFF	70	60	75

The growth performance of the purebred (Table 4) showed that the FFXFF had the higher length performance of (3.37cm) follow by MKXMK had 1.20cm, and FFXFF had 1.00cm which was the least. In week 3, the growth performance of the purebred showed that FFXFF had the higher performance with (13.20cm), follow by MKXMK had 2.67cm, while RSXRS had 2.40cm which was the least. From (WK 4) the growth performance in length showed that the FFXFF had 14.20cm, which was the higher performance, follow by RSXRS had 3.07cm, while MKXMK had 2.77cm which was the least in the week. The growth performance in length of the purebred of (week 5) showed that the FFXFF (14.20cm) had the higher growth performance in length, follow by MKXMK had 11.87cm, and RSXRS had 9.27cm which was the least. The purebred FFXFF (15.03cm) had the higher growth performance in length of the week 6, follow by MKXMK had 13.50cm, and then RSXRS had 10.53cm which was the least. From the (week 7), showed that the growth performance in length of the purebred MKXMK(15.47cm) had the higher performance in length, follow by FFXFF had 15.03cm, and then RSXRS had 14.77cm which was the least. The growth performance in length of the parent stocks from (Table 4) showed that the MK and RS had 18.43cm and 16.40cm and has the higher growth performance in length, and their reciprocal MKXFF and RSXMK gained the higher growth performance in length in (week 8), where FFXRS had 12.27cm, which was the least and there was a significant difference of the growth performance in length ($P < 0.05$).

The water quality parameters showed that the temperature also influences the time between incubation and hatching, as temperature increases, eggs hatch at a faster rate. At water temperatures ranged between 29°C – 32°C resulted in early (7hours) ovulation low temperature (20°C) resulted in prolonged the ovulation. There was a significant difference in water quality parameters ($P < 0.05$).

Table 6: Water quality parameters

Parameters	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8
Dissolve Oxygen (ml/l)	4.2	4.5	4.8	4.4	4.1	4.2	4.5	4.3
Temperature(°C)	28.5	30.5	28	29	30	29	30.5	28.0
pH	7.1	7.2	7.1	7.2	7.2	7.3	7.2	7.1

In this research, showed that the parent stocks MKXMK and RSXRS has the higher percentage fertilization (80%) and this showed that there was significant difference ($P < 0.05$) among the parent stocks. Also, the highest percentage fertilization recorded from the hybrids RSXMK, FFXRS, MKXFF and MKXRS with 91%, 85%, 85% and 84% fertilization, where 40% (FFXMK) which was observed from the hybrids respectively. There was slight difference in length observed among the crosses, Yisa *et al.*, (2017) conducted

to evaluate the growth performance of three strains of local *Clarias anguillaris* obtained from Onitsha (Rain forest), Makurdi (Guinea Savanna) and Maiduguri (Sahel Savanna) in Nigeria through intraspecific hybridization, the Maiduguri parental strain recorded highest length gain of 8.97cm and Onitsha strain hybridized with Maiduguri strain recorded 7.93cm. However, Onitsha strain hybridized with Maiduguri strain showed superiority in growth performance in both indoor (16.05 g) and outdoor (1127.43 g) experiment. The highest length gain in this work (4.86) was less than the results of Yisa *et al.*, (2017) of 8.97cm. The survival rates of the purebreds and the hybrids after 14 days under controlled hatchery conditions were high. These survival rates compared favourably with those reported in some species Nguenga, *et al*; (2000). In this research, showed that the parent stocks MKXMK has the higher percentage survival (90%) and this showed that there was significant difference ($P<0.05$) among the parent stocks. Also, the highest percentage survival recorded from the hybrids MKXRS, RSXMK and RSXFF with 85%, 83%, and 75% survival, where 40% (MKXFF) which was observed from the hybrids respectively.

This study indicates better growth performance in the side of strains from Malkohi and Research Farm. This showed the Malkohi female crossed with Fofure male and Fofure female crossed with Malkohi male had low weight gain as compared to Malkohi female crossed Research Farm male and Research Farm female crossed with Malkohi male, then Fofure female crossed over Research Farm male and Research Farm female crossed with Fofure male. This indicates that sourcing female broodstock from Research farm and Malkohi to produce viable fingerlings for farmers would be profitable business, because of the weight gain.

CONCLUSION

Generally, the pure bred MKXMK and FFXFF and its reciprocal cross RSXMK had the best performance in terms of fecundity, fertility, hatchability, survival, and growth performance; compared to the other treatments. This is an indication that, the strain of *Clarias* broodstocks from Malkohi and Fufure had influenced the growth performance. Hence it has a great potential for producing viable fingerlings for farmers to embark on profitable aqua business.

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REPRODUCTIVE AND GROWTH PERFORMANCE OF INTRASPECIFIC HYBRIDIZATION OF *Clarias gariepinus* (Burchell 1822) STRAINS

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ABSTRACT

In this study, the reproductive and growth performance of intraspecific hybridization of *Clarias gariepinus* strains from two geo-political zone of Nigeria namely: Nguru from Yobe state designated as (NG) and Argungu from Kebbi state designated as (AR) were examined based on the differences in the percentage fecundity, sperm volume, fertilization, hatchability, survival and growth performance, the fish were conditioned, fed and spawned in the Modibbo Adama University, Fisheries research farm; for the period of 8 weeks in a semi-flow through system, in the indoor hatchery using plastic bowls filled with 20 litres of water, the eggs and milt was cross fertilized, in which after hatching 20 fry each from the parental crosses and their reciprocals hybrids were randomly selected and stocked in each bowl of 4 treatments with 3 replicates each. High fecundity rate was recorded in AR♀ with 31,480 numbers of eggs while that of NG♂ with 21,300. This study revealed high testes weight and milt volume in AR♀ strain and least was obtained in NG♀ strain. The cross between AR♂ x AR♀ had the highest fertilization rate (90%) and the least in both AR♂ x NG♀ and NG♂ x NG♀ with (70%) and there was no significantly between the two crosses ($P > 0.005$). The cross between AR♂ x NG♀ had the best hatchability rate (100%) while the least in NG♂ x AR♀ (88%). The cross between NG♂ x NG♀ had the best survival rate (71.4%) and the least in NG♂ x AR♀ (47.1%), highest mean weight gained was 59.7 ± 0.15 (NG♂ x AR♀) while the least was 30.30 ± 0.79 (NG♂ x NG♀) while the mean increase in length were 16.30 ± 0.20 (NG♂ x AR♀) and least 12.46 ± 0.25 (AR♂ x AR♀). The cross between (NG♂ x AR♀) should be recommended to the farmers for culture in order to achieved profitable production.

Keywords. Reproductive, *Clarias gariepinus*, Fertilization, Hatchability, and Growth.

INTRODUCTION

Aquaculture is viewed as an important tool to close the gap between supply and demand of animal protein in Nigeria. National demand stands at 2.1 million metric tons per annum while national production from both capture and aquaculture stand at 800,000 tones (Aquaculture and Inland Fisheries Project, 2014). In Nigeria about 1.3 million metric tonnes of fish are imported to meet the annual demand (Federal Ministry of Agriculture, 2015). Production from capture fisheries is estimated to be at a maximum sustainable level. The aquaculture system in Nigeria is largely dependent on *Clariid* catfishes (70 percent), tilapia, with smaller contributions from mullets and carps to total production (FAO, 2020). Fish has been reported (Federal Department of Fisheries 2017) to be an important and the cheapest source of animal protein which accounts for about 37% of Nigeria's total protein requirement. Meanwhile it is undisputable that aquaculture has been deemed the only alternative for high quality protein production to meet the nutritional needs of the ever increasing world population because capture fisheries is showing precipitous decline due to over fishing, habitat destruction, and pollution (Olaleye 2011).

Fingerlings production and availability of quality fish feeds have been the bane of fish farming development in Nigeria for the past four decades and stressed the need for increased production of fingerlings to meet the ever rising fish demand (Jimoh *et al.*, 2010; Adebayo and Popoola, 2018 and Potongkam and Miller 2016). Reproduction techniques is one of the factors that affect the performance of any fish farm or hatchery as it can either be natural or artificial. The output of the natural propagation in fish is very low and cannot meet the protein requirement of its consumers (FAO, 2016). In view of this, an artificial propagation techniques under more controlled conditions has been discovered to produced reliable source of fish and fingerlings (FAO, 2016). Crossbreeding is used to evaluate performance and achieve improved traits (heterosis), minimize inbreeding and obtain better hybrids (Jothilakshmanan and Marx, 2013). Fish from different water bodies that are not interconnected expected to have different strains performance and strains crosses has also

been successful in evaluating and improving reproductive traits, growth rates like daily weight gain, specific growth rate, survival rate (Hassan *et al.*, 2011). Fish hybridization is one of the genetic techniques which help to remove undesirable traits while retaining only the desirable ones. Hence the need for intraspecific hybridization to produce fast growing hatchlings. The objectives of this study include to determine fecundity of the females, percentage fertilization, hatchability, survival and evaluate growth performance using four (4) crosses of *Clarias gariepinus* from two geo-political zones.

MATERIALS AND METHODS

Study Area. The study was conducted in Department of Fisheries, Teaching and Research farm, Modibbo Adama University Yola, Adamawa State, Nigeria. It is located on latitude 9.2°-9.33° longitude 12.3- 12.5° E and an altitude of 185.9m. It has an average annual rainfall of about 759mm with maximum temperature of 39.7°C. (Canback Global Income Distribution Database, 2014).

Broodstock selection, hypophysation, experimental design and set-up

Male and female each were randomly selected from Argungu river and Nguru wetland which are not interconnected water bodies and transported down to the Teaching and Research fish farm of Department of Fisheries and used for fingerlings production. The broodstock with weight between 350g and 600g females and 600g and 700g males were injected according to Onyia *et al.*, 2020. Each cross was a treatment in this study and each treatment were replicated thrice in a completely randomized design (CRD), which makes a total of four experimental units. Twelve (12) plastic bowls (15-25 litres water capacity) was used for the experiment. The sperm and egg qualities of the broodfish were taken. Each experimental unit with replicates was stocked with 20 fertilized eggs and percentage hatchability were observed. Each bowl was filled with water up to 10-20 litres capacity after hatching, using a flow through. Four (4) days old hatchlings were randomly distributed into plastic bowls (20L) with 20 hatchlings in complete randomized design in triplicates. The hatchlings were copped for 56 days and the results of the study are statistically presented in histogram.

RESULTS AND DISCUSSION

The results weight of eggs, number of eggs in 1g, total number of eggs/broodstock, egg diameter and gonado-somatic index (GSI) are presented in Table 1. The broodstock from Argungu had the higher weight of eggs and total number of eggs. Whereas, Nguru broodstock had higher number eggs/1g and GSI. On some of sperm quality (Fig. 1), Argungu had better length of left and right lobes of testis, as well as milt volume.

Table 1. Mean fecundity and Gonado-somatic index of different strains of Females *Clarias gariepinus* from Nguru and Argungu

Parameters	NG♀	AR♀
Weight of Broodstock (g)	350	600
Total length of broodstock (cm)	32	41
Weight of egg (g)	30	45.10
Number of eggs in 1g	710	698
Total Number of eggs by a fish	21,300	31,480
GSI	8.6	7.5
Egg diameter	0.8	0.9

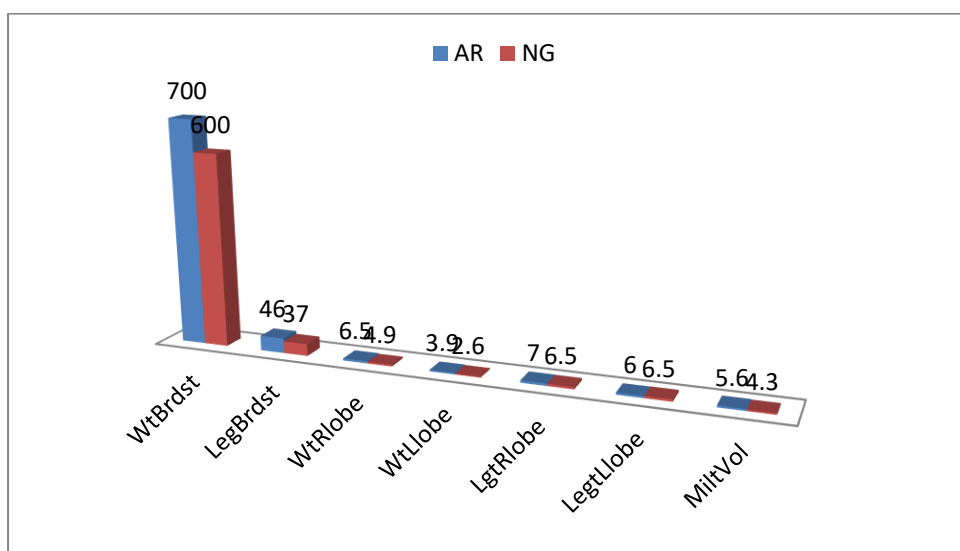


Fig. 1: Some sperm quality of Broodstock

KEYS. WtBrdst- weight of broodstock, LegBrdst- Length of broodstock, WtRlobe- Weight of right lobe, WtLlobe- Weight of left lobe, LgtRlobe- Length of right lobe, LgtLlobe- Length of left lobe, and Miltvol- Milt volume.

From, the crosses (figures 2), AR♂xAR♀ had the highest percentage fertilization, followed by NG♂ xAR♀ while AR♂xNG♀ and NG♂xNG♀ had the same (70%). The best hatchability was in AR♂xNG♀, followed by NG♂xNG♀, AR♂xAR♀ and NG♂xAR♀. The best survival rate was in NG♂xNG♀ and least was in NG♂xAR♀. From figure 3, the reciprocal crosses had the best weight gain, specific growth rate and Final weight.

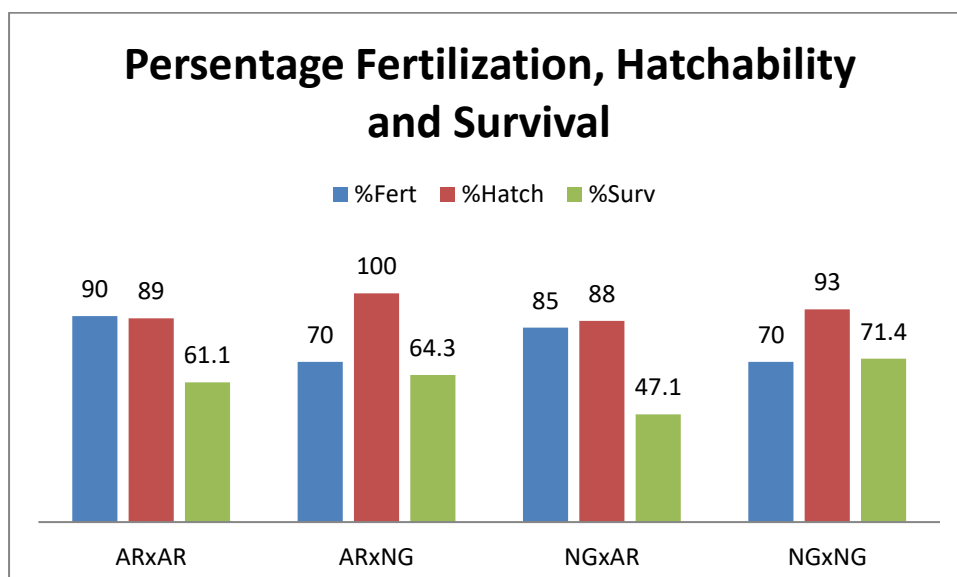


Fig. 2: Percentage Fertilization, Hatchability and Survival of genetic crosses compared
Keys: AR- Argungu, NG-Nguru

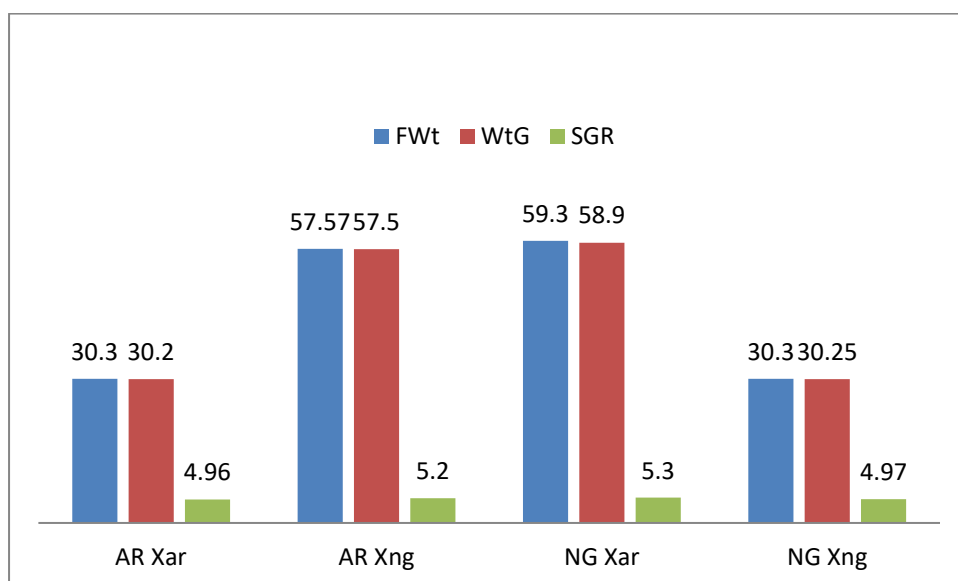


Fig. 3: Final weight, weight gain and specific growth of parental and reciprocal crosses of *C. gariepinus*

From the results of this study, the broodstock from Argungu had better fecundity and milt volume than that of Nguru; this could be as a result of the kind feed the broodstock fed in environment the where each was collected. Several authors have reported that the type of feed give to fish influence the reproductive performance of broodstock (Dada *et al.*, 2015; and Onyia *et al.*, 2019). This also can be inferred why Argungu broodstock had higher milt volume than Nguru. Whatever influences the reproductive performance of broodstock to produce viable fingerlings must also affect the percentage fertilization, hatchability and survival. Among the parental crosses, Argungu had better percentage fertilization but Nguru had higher hatchability and survival. However, the reciprocal crosses overall best highest fertilization, hatchability and survival. This agree to the fact that reciprocal crosses (hybrids) utilizes the genetic traits of both parents to have better performance than the parents. This is affirmed by the work of Akankali *et al.* (2011) who reported that apart from being able to obtain quality seed, the artificial intraspecific hybridization can also be used to develop strains superior to their parents. In the same light, the hybrids had better final weight, weight gain and specific growth rate at the end of the study.

CONCLUSION

From this result reciprocal cross from Nguru and Argungu is recommended to farmers and hatchery managers because of its reproductive performance and growth.

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BREEDING RESPONSE AND PROGENY SURVIVAL OF TWO STRAINS OF *CLARIAS ANGUILLARIS* (LINNAEUS 1758) FROM SOUTH EAST AND SOUTH WESTERN NIGERIA

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ABSTRACTS

The study evaluate the breeding response of *Clarias anguillaris* from South East and South Western Nigeria, with the aim to improve the hatchability and progeny survival. The research established significant increase in the hatchability and survival of the F1. The hybrids from the cross had the best hatchability (100%) and survival, Ijebuode and Awka (95%) and Awka and Ijebuode (97%) respectively. While the fecundity were significantly ($P<0.05$) high in female parent from Ijebuode (82,544) Awka (71,162), the same trend were observed in the milt volume (5.2ml) and Awka (4.6ml). Fish of high breeding potential can be obtained through hybridization. Therefore, the quality of the water used should be determined to minimize poor hatchability, survival and loss of eggs and progenies.

Key words: Intraspecific hybridization, Fecundity, hatchability, Progeny and Survival

Introduction

Fish eggs and sperm is a valued factor in aquaculture development Rizzo and Bazzoli, (2020); Ochokwu *et al.* (2016). Obtaining a gravid female and male with matured testis and considerably amount of milt that can fertilize the eggs is essential in fish populace and aquaculture (Segner, 2011; Agbebi *et al.*, 2013). Bardon-Albert and Saillat (2017) previously reported that the attributes of the gonad is correlated to the fertility and hatchability of the eggs and growth of the hatchlings in fish breeding. The emphasis on eggs comprises of fecundity and gonadosomatic index. Bradshaw and McMahon (2008) described fecundity as an essential output of female fish over a breeding season and the major theoretical and applied population biology. Furthermore, he emphasized that fecundity relate with the genetic composition and growth of the fish. GSI is used to measure sexual maturity in relation to the sexual development of the ovaries or testes (Rizzo and Bazzoli, 2020), however, it is attributed to the gonad weight as a percentage of the total body mass (Flores *et al.*, 2018). Hence, the fertility rate ensures hatchability success if the water quality parameters of the water are in right proportion. Fertility in fish measures the viability of the milt and its influence to the hatchability percentage (Petersen and Warner, 2002).

African mud Catfish is one of the most researched fish species in African, it is of economic value and acceptable fish species (Ochokwu *et al.*, 2019), catfish such as *Clarias gariepinus*, *C. anguillaris* among others can be hybridized (Adah *et al.*, 2014).

Hybridization have been effectively utilized to improve fish, it improved the growth and heterosis in fish, it have reduced inbreeding, hybridization is also an essential method for removal of undesirable trait in fish strains (Adah *et al.*, 2014). The problem that have affected aquaculture sustainability in south eastern Nigeria are poor hatchability of the fertilized eggs (Ochokwu *et al.*, 2020), high rate of mortality of the F1 after one to two weeks of hatching, the physicochemical parameters of the pond water, majorly the water pH, temperature (Pankhurst, 2016). During the short period I worked in the region (Ekelem farm), *C. anguillaris* from Ijebuode (Ogun State) and Awka (Anambra State) were cross to evaluate the breeding performance and how to minimize the mentioned limitations and increase fingerlings survival.

Materials and Methods

The research was investigated in the hatchery unit of Ekelem's Fish Farm in Awka from the month of July 2017 to April 2018. Awka is the state capital of Anambra State. The state is bounded by latitudes 6° 10'N and 6° 17'N and longitudes 7° 2.4'E and 7° 7.2'E (Nzoiwu *et al.*, 2017). The mean annual rain fall is 1900.5mm.

Experimental design

Sixteen (16) *C. anguillaris* strains with average weight of 800 to 2000g were purchased from Ijebuode (madam Felima fish farm) and Awka (Jude's mini fish farm). The brood fish were transported to the hatchery unit. The broodstock underwent an acclimatization period of 48 hours before the commencement of the research.

Artificial fertilization and hatchability

The broodstock both male and females were sexed, weighed and induced with the ovulin at 0.5ml/kg of body weight and male 0.2ml/kg according to (Ochokwu *et al.*, 2016). The latency period was 10 hours at temperature of 26°C. 50 eggs from each strains were crossed in triplicates in a complete randomized block designs (CRBD) as female Ijebuode and male Ijebuode (IJ x IJ), female Awka and male Awka (AW x AW), female Ijebuode and male Awka (IJ x AW) and female Awka and male Ijebuode (AW x IJ) and were fertilized using 0.2ml of the milt. The fertilized eggs were stirred for 5minutes, and the translucent eggs with embryonic eyes during polar cap formation were considered fertilized. The F1 and the un-hatched eggs from each cross were counted. The fertilization and hatchability were calculated as follows: Fertilization rate (%)

$$= \frac{\text{Number of fertilized eggs}}{\text{Total number of eggs}} \times 100$$

$$\text{Hatchability (\%)} = \frac{\text{Number of hatchlings}}{\text{Total number of fertilized}} \times 100$$

$$\text{Fecundity} = \text{number of eggs in 1g} \times \text{total weight of stripped eggs}$$

$$\text{Gonadosomatic index} = \frac{\text{weight of Ovary}}{\text{body weight (g)}} \times 100 \text{ (Viveen et al., 1985; Ochokwu et al., 2016).}$$

Statistical analysis

The data were analyzed with one way analysis of variance (ANOVA). While Duncan Multiple Range Test DMRT were used to compare the differences between the means (P) = 0.05 using SPSS 20.0.

Results

Table 1 represents the fecundity and gonadosomatic index of *C. anguillaris* parent from Ijebuode and Awka. The fecundity rate was high in female from Ijebuode (82,444) while Awka had (71162).

The testis weight and volume is shown in table 2. The milt volume was high in male parent from Ijebuode (5.2) while Awka had (4.6). While the fertilization, hatchability and survival of the hatchlings from the genetic cross are revealed in table 3. The hatchability and survival were 98 and 91% for Ijebuode, 95 for Awka and the cross were IJ x AK 100, 97 and AK x IJ 100 and 95 respectively.

Table 1 The fecundity and GSI index of female *C. anguillaris* from Ijebuode and Awka

Strain	Weight g	Length cm	Weight of ovary	Eggs in 1 g	Number of eggs	GSI
Ijebuode	1500 ^a	51.2 ^a	154.0 ^a	536 ^a	82544 ^a	10.27 ^a
Awka	1200 ^b	48.1 ^a	91.0 ^b	782 ^b	71162 ^b	7.6 ^b

Means in each column with the same superscript are not significantly different ($P>0.05$)

Table 2 The testis weight, length, and volume of male *C. gariepinus* from Ijebuode and Awka

Strain	Weight (g)	Length cm	Weight of testes (g)	Lt of left lobe (cm)	Lt of right lobe	Milt volume ml
Ijebuode	2200 ^a	56.8 ^a	5.20 ^a	3.2 ^a	2.5 ^a	5.2 ^a
Awka	2000 ^b	54.2 ^a	3.70 ^b	3.8 ^a	2.2 ^a	4.6 ^a

Means in each column with the same superscript are not significantly different ($P>0.05$)

Table 3 The fertility, hatchability and survival rate *C. gariepinus* from Ijebuode and Awka after treating the water with soda ash

Genetic cross	No of fertilized eggs	% Fertility	No of hatched eggs	% hatchability	% survival after 7 days
IJ × IJ	50 ^a	100 ^a	49 ^b	98 ^b	91 ^b
AK × AK	47 ^a	94 ^c	45 ^a	95 ^b	95 ^a
IJ × AK	49 ^a	98 ^b	49 ^{bc}	100 ^a	97 ^a
AK × IJ	48 ^a	96 ^{bc}	48 ^c	100 ^a	95 ^a

Means in each column with the same superscript are not significantly different ($P>0.05$)

Table 4 Water quality parameters of the of the rearing pond

Genetic cross	T (°C)	pH	DO (mg/l)	Total dissolved solid	Turbidity
IJ × IJ	27	7.0	5.3	11.8	12.5
AK × AK	27	7.0	5.3	11.8	12.5
IJ × AK	27	7.0	5.5	11.9	12.5
AK × IJ	27	7.0	5.5	11.9	12.5

DISCUSSION

The cross between *C. anguillaris* from Ijebuode and Awka was carried out to improve the hatchability and survival of the F1. The result revealed high fecundity among the strains, however, the strain from Ijebuode had the highest fecundity (82,544), milt volume (5.2ml) and hatchability rate (98%), while Awka had fecundity 71,162, milt volume 4.6 and hatchability (95%). The hybrids had the highest hatchability (100%) and survival. The use of sodium carbonate to raise the pH of the water improved the hatchability and survival of the hatchlings, the hatchability rate recorded in this research hence agreed with previous report by Olufeagba *et al.*, (2015). Meanwhile Ochokwu *et al.* (2016) stated that hybridization is an essential factor towards improving the F1 generations and indigenous fish which have record of poor hatchability and survival. Hence, the differences recorded in the breeding trials were as a result of low pH. Meanwhile, water temperature, variations in season were previously reported by Shah *et al.* (2011) as another possible factor that can cause poor hatchability in fish breeding. The high fecundity recorded from Ijebuode agreed with Ochokwu *et al.* (2016) who observed high fecundity in *C. gariepinus* from Ibadan. Moreover, it was also observed that fat content in the abdomen of the fish affect the fecundity of the fish, hence the higher the lipid the lower the fecundity this agreed with Dahlgren (1981) who stated that fish require certain amount of protein to improve and maintain a relatively high fecundity.

CONCLUSION

The study on intraspecific hybridization between *C. anguillaris* strains from jebuode and Awka exposed the major cause of poor hatchability and mortality of the fry, which were caused by low pH (4.1). However, the use of sodium carbonate significantly improved the pH of the water hence lead to increase in the hatchability and survival of the hatchlings.

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Reproductive strategy of African carp, *Labeo coubie* (Ruppell, 1832) in Upper Benue River, Nigeria

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ABSTRACT

The African carp, *Labeo coubie* is a culturable fish species in Nigeria with dearth of formation on reproductive biology of the species relevant for its propagation. The reproductive strategy was investigated through determination of sex ratio, fecundity, length at sexual maturity, gonadosomatic index (GSI) and spawning season in the Upper Benue River in Nigeria where the species is of economic importance. Fish

specimens were collected monthly from the landing site of local fishermen at Jimeta, Yola from September, 2017 to February, 2019. Morphometric measurements including standard length and body weight were recorded for a total of 849 specimens. Gonad weight was measured to determine GSI. Fecundity of *L. coubie* was fairly high, with absolute fecundity range of 33,331 and 596,250 eggs (mean $78,017 \pm 165,667$) from females of mean weight $4,800.00g \pm 0.00g$, mean length $51.6cm \pm 2.97cm$; The sex ratio, 1:0.9 was in favour of the males and it is insignificantly different ($p > 0.05$) from expected 1:1. The length at first sexual maturity, L_{50} , were 31.3cm and 32.1cm for males and females respectively. Highest GSI of 1.17 and 8.71 for males and females respectively were observed in July. *Labeo coubie* was a multiple spawner over an extended period of April to November in the river, with minor peak spawning in April and November and a major peak in July. To ensure steady recruitment of the species in Upper Benue River, its exploitation should be restricted during the spawning season. Manipulation of *L. coubie* for artificial spawning will be best in July (major peak spawning period) which falls within the peak of the rainy season in Upper River Benue.

Key words – *Labeo coubie*, Fecundity, Gonadosomatic index, Spawning season, Upper River Benue

Introduction The African carp, *Labeo coubie* is an important species inhabiting many major rivers in Africa, including Nigeria, Senegal, Gambia, Ivory coast, Liberia, Zaire and Gabon (Ikpi *et al.*, 2012). Out of the eight known genera of the African carp family, *Labeo* and *Barbus* are more common in the Nigerian inland waters. *Labeo* species constituted about 10.3% of the total catch collected in randomly-selected villages along the northern and southern banks of River Benue and 8% relative proportion by weight (FAO, 2017). *Labeo coubie* is characterized by good taste and it is a rich source of protein. Study of the reproductive system and strategy of fish species provides information necessary for determining the reproductive pattern of the species. Determination of the reproductive pattern according to Mgbenka and Eyo (1992) and Abobi *et al.* (2015), is essential to manage and improve the fishery of any species, since reproductive stage is a link in the life history of the fish (Ragheb, 2016). Information about such parameters as age and size at maturity, fecundity, milt volume, fertilization rate, hatchability and survival rate of larvae will invariably serve as baseline information for the propagation and management of fish species. The African carp, *Labeo coubie* is not as widely cultured in Nigeria as mud catfishes, despite the fact that it also has the potential to grow fast and has a good market value. Unsuitable to *L. coubie* management and thus inadequate availability of its seeds for stocking are some of the key problems facing its culture in Nigeria. This study therefore seeks to unravel some peculiarities of the reproductive biology of *L. coubie* in a major inland freshwater, UBR, in order to enrich the available information on the topic and possibly sustain an extensive culture of the species.

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 $9^{\circ} 16' N - 9^{\circ} 19' N$ and $12^{\circ} 26' E - 12^{\circ} 29' E$, 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 $12^{\circ} 27.8'E$. Fish specimens were collected from the landing sites 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 in plastic tanks with ice packs to the laboratory of Department of Fisheries, Modibbo Adama University, (MAU), where morphometric measurements of the fish were taken. 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.

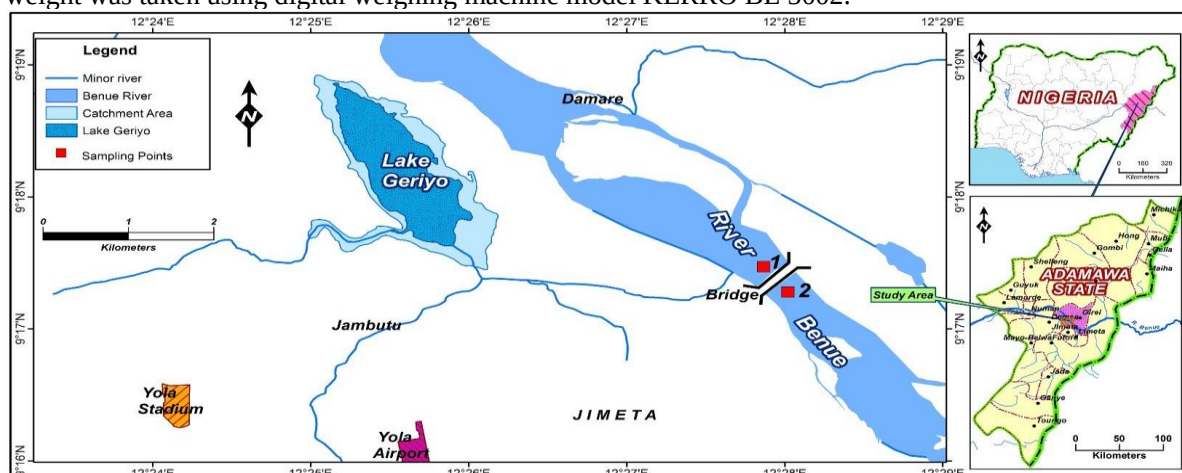


Figure 1. Map of Upper River Benue showing sampling stations

Sex determination and sex ratio Sex of large and gravid specimens collected was determined macroscopically according to FAO (1996) and Jhingran and Pullin (1985), while microscopic methods (Jhingran and Pullin, 1985; Morrison *et al.*, 2006) were used to determine the sex of smaller specimens found with gonads. Some criteria used for sex recognition were bulging and soft abdomen with slightly swollen, convex and reddish vent in females. Male fish body was rather oblong, with vent opening concave (pit-like) and pale. Results of gonad histology also complimented the methodology of determining the sexes of specimens. In younger and immature samples, results of gonad histology were used to determine the sex. Sex ratio was calculated based on the proportion of males and females in the collected samples.

Fecundity was determined using gravimetric sub-sampling wet method described by Bagenal (1978). Ovaries of females in stage III (mature and spawning-capable) were used to determine fecundity according to the criteria of Jhingran and Pullin (1985). The ovaries were removed and weighed after removing excess water on filter paper. One gram of egg mass was weighed and placed in a petri dish. The number of eggs in this mass was counted. An estimate of the total number of eggs in the ovaries was then made by extrapolation from the total number of eggs in 1g.

$$\text{fecundity} = \text{number of eggs in 1g} \times \text{mass of ovaries}$$

Size at maturity The size at maturity was taken as the minimum length at which 50% of the males and females sampled are found with mature gonads (L_{50}). This was determined using the Length-Frequency Analysis Wizard of Fishbase and Microsoft Excel 2007 packages.

Breeding season Breeding season of *L. coubie* was determined from percentages of fish with ripe gonads sampled each month between September 2017 and February 2019, according to Hossein and Ohtomi (2008) and also from rise in GSI (Hossein *et al.*, 2017).

Data analyses Chi-square was used to analyze differences in sex ratio. Fecundity and GSI data were subjected to descriptive statistics using simple line graphs. Statistical significance of difference in means of values was considered at $p < 0.05$.

Results

Sex ratio of *L. coubie*

Figure 2 shows the proportion of males and females during the study period between September, 2017 and February, 2019. Four hundred and seven (407) individuals (48%) out of the 856 specimens collected were females and 449 (52%) were males. The Chi-square test showed that there was no significant ($p \leq 0.05$) deviation of the observed ratio of females to males (0.9:1) from the expected 1:1, since the calculated value (chi-square value = 2.061, d.f = 1) is less than tabulated value (3.84).

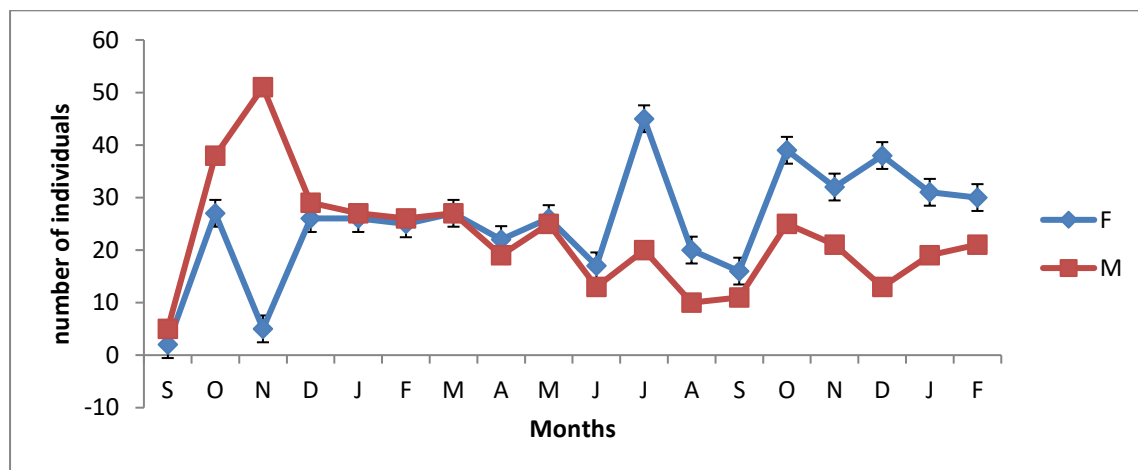


Figure 2. Monthly Population of *L. coubie* by Sex

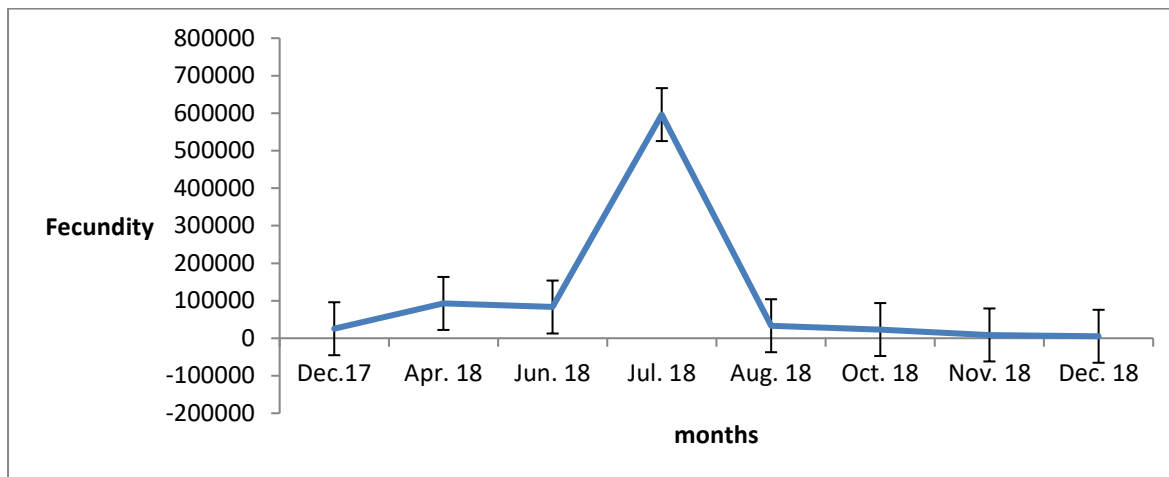


Figure 3. Mean fecundity of *L. coubie*

The fecundity of gravid *L. coubie* ranged between 33,331 eggs and 596,250 eggs, with a mean of 139,751. The monthly fecundity is illustrated in **Figure 3**. Relative fecundity varied from 2.09 eggs.g⁻¹ to 124.22 eggs.g⁻¹ and 120 eggs.cm⁻¹ to 12,045.5 eggs.cm⁻¹.

Labeo coubie in the present study had multiple GSI peaks in December 2017, April 2018, July 2018 and November 2018, with a most prominent peak in July, observed in the female (**Figure 4**). The lowest mean GSI, 0.19 and 0.28 for males and females respectively, were observed in the month of October, 2018, while the highest values, 1.17 and 8.71 were observed in July, 2018.

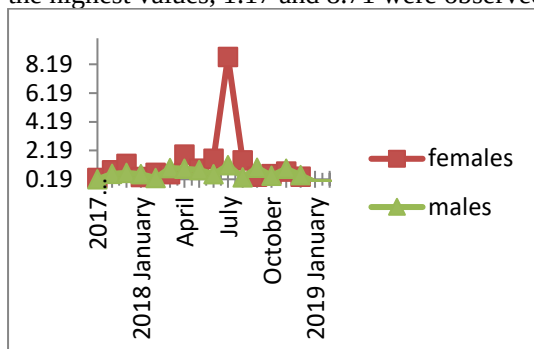


Figure 4. Gonadosomatic indices of *L. coubie* in monthly samplings

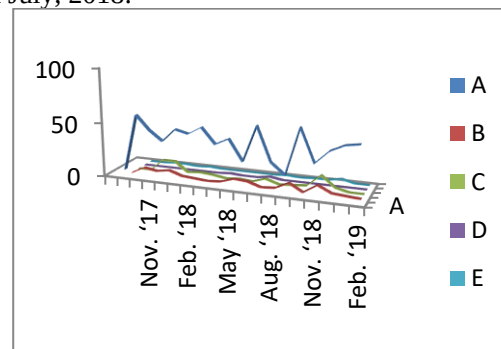


Figure 5. Proportions of different cohorts of *L. coubie*

A- immature; B- maturing; C – mature/ spawning-capable; D- spawning; E- spent *L. coubie*

Size at maturity Females of *L. coubie* at Upper Benue River reached maturity at standard length 31.3cm, while the males matured for the first time at length 32.1cm.

Breeding season The proportions of *L. coubie* found with ripe gonads were relatively higher in the months of November and December (from 1 to 13) and also during the peak of the rainy season in July, 2018 (2)

Discussion The sex ratio of male to female fish observed in this study (1:0.91) was insignificantly ($p > 0.05$) different from the hypothetical ratio of 1:1. The result compares fairly with those of other researchers. Offem *et al.* (2009) observed a ratio of 1:1.2 for *L. coubie* in the tropical wetlands of Cross River. Ikpi and Okey (2011) discovered a ratio of 1:0.92, 1:0.83 and 1:0.82 for *L. coubie* upstream, midstream and downstream respectively, of Agbokim waterfalls in Cross river state. Achionye-Nzeh (2010) on the other hand, reported a closer to hypothetical sex ratio of 1:1 for *L. coubie* in a reservoir in Ilorin. Tiogue *et al.* (2013) however observed a ratio of 1:1.42 for a closely-related species, *Labeobarbus batesii* in the Mbo Floodplain river of Cameroon. Most of these ratios are comparable with the result of the present study apart from that of Tessema *et al.* (2020), who reported 1.3:1 for Common carp in Lake Hayq, Ethiopia.

High fecundity observed for *L. coubie* could be seen as a reproductive strategy adopted by the species to ensure better survival of its seeds. Fish seeds in natural waters usually suffer high level of exposures to unfavorable environmental conditions, such as high tide, drought, and also influence of multiple predators, like insects and fish.. Increase in GSI was observed in the periods between December 2017 and November 2018. *L. coubie* in the present study had multiple GSI peaks in December 2017, April 2018, July 2018 and November 2018, with a most prominent peak in July, observed in the female. Multiple GSI peaks could

characterize a fractional multiple spawning which might also suggest advantages of reduced larval crowding, low impact of predation and unfavourable environmental conditions on eggs and larva (Dorostghoal *et al.*, 2009; Tiogue *et al.*, 2013). This analysis of reproductive strategy of the African carp could possibly be used to explain the logic behind high population of young immature fish in the river (**Fig. 5**).

Female individuals of *L. coubie* in the present study mature at shorter length (31.3cm), compared to their male counterparts (32.1cm). These values are comparable to those reported for *Labeobarbus batesii* – 20.3cm and 21.3cm in the Mbo Floodplain rivers of Cameroon (Tiogue *et al.*, 2013) and for *Labeo senegalensis* – 25.7cm and 29cm in the Queme basin, Benin (Montchowui *et al.*, 2010). Observed differences in size at maturity in these instances are obviously due to species differences, more importantly, and also environmental factors.

Breeding season of *L. coubie* in the present study was found to spread over several months within a year, with a major peak in July, which coincides with rains and floods in UBR. Spawning in fish species, particularly labeine species has been reported to be synchronized with peak of the rains (Rutaisire and Booth, 2005). The trend in egg size in this study also showed that the period when the eggs were most robust coincided with the peak of the rains.

This strategy, apart from the high fecundity exhibited by this species, can also be seen as a mechanism adopted to ensure better survival of spawn.

Conclusion This study provided information on the reproductive condition of *L. coubie* in Upper Benue River, Nigeria. It showed that absolute fecundity was higher than observed data from other Nigerian inland waterbodies. Breeding in *L. coubie* was cyclic and extended over a period of eleven months, which led to availability of high population of young immature fish in the river throughout the year.

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GENETIC STRUCTURE OF *Clarias gariepinus* FROM CULTURE AND WILD ENVIRONMENT

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ABSTRACT

Sustainability of the African catfish, *Clarias gariepinus* as one of the most important fish species in Nigeria freshwater resource is highly dependent on genetic diversity and adaptability of the species. There is inadequate information on the genetic structure of the *Clarias gariepinus* in freshwater lakes in Nigeria. This study therefore investigated genetic structure of *C. gariepinus* in Lamingo lake. *C. gariepinus* collected from wild and culture environments were used to study genetic structure by examining variability in genotypes. Samples were screened for Private Allele, DNA bands and genetic diversity using Random Amplified Polymorphic DNA (RAPD) marker. Evolutionary analysis was done by Maximum Likelihood method and cluster analysis. A total of 602 individual bands were obtained from a total of 43 detected loci, which gave 38.4% polymorphism. Gene diversity ranged between 0.847 to 0.918. Polymorphic Information Content (PIC) ranged between 0.829 to 0.912. The pooled samples formed two main clusters in which 85.71% of wild samples clustered and diverged from 85.71% of cultured samples. The wild species were more polymorphic and more genetically diverse. The admixture going on between the wild and culture environment is a threat to the fish in the wild environment as it is leading to loss of adaptive traits of *Clarias gariepinus* in Lamingo lake.

Keywords: *Clarias gariepinus* Lamingo Lake, Genetic structure

INTRODUCTION

African catfish, *Clarias gariepinus* is one of the most important fish species in Nigeria fresh water, either as culture or wild fish. *C. gariepinus* is the most farmed fish species in Nigeria, accounting for over half of aquaculture production by volume (FAO., 2018). Fish constitute a major percentage of biological diversity of organisms that inhabit rivers and other water bodies (Asagbara *et al.*, 2014). *C. gariepinus* has high fecundity and high reproductive fitness (Absalom *et al.*, 2017), flexible phenotype, fast growth, wide range of habitat preferences, tolerance of extreme weather conditions and ability to survive on a wide variety of prey or feed.

Fisheries and aquaculture sector is important to millions as source of animal protein, livelihood among others. Meanwhile, catch from capture fisheries is dwindling and at the rate of global exploitation, it is becoming unsustainable (Gabriel *et al.*, 2007; Welcomme *et al.*, 2010 and Huang *et al.*, 2020). Aquaculture activities are increasingly compensating for the drop in yield from the capture fisheries. Unfortunately, aquaculture activities are a growing threat to wild aquatic lifeforms (Tezzo *et al.*, 2020)

It is well known that genetic diversity is the natural system defense that is available for species in combating diseases and increasing chances of survival even to unfavorable environmental conditions and is also the natural means of knocking out unfavorable traits in species. This makes it possible for an organism's ability to thrive in various environments (Chauhan and Rajiv, 2010). Meanwhile, increasing human interference such as fishing and introduction of alien species threatens genetic integrity of indigenous fisheries. It calls for attention to notice that the species abundance is declining in the world at large (Vanderklift *et al.*, 2019).

ASSESSMENT OF GENETIC STRUCTURE AND VARIABILITY OF RAPD MARKER

The use of RAPD marker for this study is based on the fact that it can generate large number of loci, it is relatively less expensive, and it does not require a prior information of the DNA sequence to perform the

assay, hence it was used for this study. Fish taxonomic guide (Guide to Freshwater Fish) by Olaosebikan and Raji (2004) was used for sample identification process. The samples were further screened using number of dorsal and anal fin ray counts (61-80 and 45-65 respectively) following the description of species by Teugels (1986). Fourteen fish samples were randomly selected from the pool of samples. Tissue from the dorsal fin was taken with a surgical scissors and preserved in labeled sampling bottle, submerged in 100% ethanol and kept in the freezer. Approximately 100 mg of tissue from the fin was grinded with Dellaporta extraction buffer. Each sample was grinded in 1000 µl of the buffer in a sterilized sample bag. Mix was collected in sterile eppendorf tube and 40 µl of 20% SDS was then added, this was followed by brief vortexing and incubated at 65°C for 10 minutes. At room temperature, 160 µl of 5 M potassium acetate was then added, vortexed and centrifuged at 10000 g for 10 minutes. The supernatant was collected in another eppendorf tube and 400 µl of cold iso propanol was added mixed gently and kept at -20 °C for 60 minutes. To precipitate the DNA, it was then centrifuged at 13000g for 10 minutes. The supernatant was gently decanted and ensured that the pellet was not disturbed. DNA was then washed with 500 µl of 70 % ethanol by centrifuging at 10000g for 10 minutes. Ethanol was decanted and DNA air-dried at room temperature until no trace of ethanol was seen in the tube. Pellet was then re-suspended in 50 µl of Tris EDTA buffer to preserve and suspend the DNA.

Approximately 100 mg of tissue from the fin was grinded with Dellaporta extraction buffer. Each sample was grinded in 1000 µl of the buffer in a sterilized sample bag. Mix was collected in sterile eppendorf tube and 40 µl of 20% SDS was then added, this was followed by brief vortexing and incubated at 65°C for 10 minutes. At room temperature, 160 µl of 5 M potassium acetate was then added, vortexed and centrifuged at 10000 g for 10 minutes. The supernatant was collected in another eppendorf tube and 400 µl of cold iso propanol was added mixed gently and kept at -20 °C for 60 minutes. To precipitate the DNA, it was then centrifuged at 13000g for 10 minutes. The supernatant was gently decanted and ensured that the pellet was not disturbed. DNA was then washed with 500 µl of 70 % ethanol by centrifuging at 10000g for 10 minutes. Ethanol was decanted and DNA air-dried at room temperature until no trace of ethanol was seen in the tube. Pellet was then re-suspended in 50 µl of Tris EDTA buffer to preserve and suspend the DNA.

Polymorphic six (6) RAPD markers were used for genotyping the entire genome of the 14 samples. Total PCR reaction was optimized to be 15 µl and this included 2 µl of about 100 ng DNA template, 7.0 µl Dream Taq PCR master mix (Thermos Scientific Inc.), 2 µl of each SSR primer, and 4.0 µl nuclease free water. PCR protocol was followed, this consisted of an initial denaturation at 94°C for 5 mins followed by 35 cycles of denaturation of 94°C for 15sec Annealing of 37°C for 20sec and extension of 72°C 30sec then a final extension of 72°C for 7 mins and chill at 4°C.

Table 1: Name of primers used with their respective primer sequence

Primer name	Forward primer sequence
OPH-04	GGAAGTCGCC
OPH-08	GAAACACCCC
OPT-01	GGGCCACTCA
OPT-02	GGAGAGACTC
OPT-08	AACGGCGACA
OPT-17	CCAACGTCGT

The separation of bands as produced by each primer was done in a 1.5% Agarose gel. The buffer (1XTAE buffer) was prepared and subsequently used to prepare 1.5% agarose. The suspension was boiled in a microwave for 5 minutes. The molten agarose was allowed to cool to 60°C and stained with 3µl of 0.5 g/ml Ethidium Bromide. The Ethidium Bromide absorbs invisible UV light and transmits the energy as visible orange light.

A comb was inserted into the slots of the casting tray and the molten agarose was poured into the tray. The gel was allowed to solidify for 20 minutes to form the wells. The 1XTAE buffer was poured into the gel tank to barely submerge the gel. 7 µl of 100bp DNA ladder was loaded into the first well (well no. 1). Each PCR product were loaded into the remaining wells. The gel was then electrophoresed at 120V for 45 minutes. After electrophoresis, the electrophoresed gel was visualized by ultraviolet trans-illumination and photographed. The sizes of the PCR products were estimated by comparison with the mobility of a 100bp molecular weight ladder that was ran alongside experimental samples in the gel.

STATISTICAL ANALYSIS

The statistical tools used for this study are presented in this section.

Assessment of Genetic Structure and Variability of Rapid Marker

RAPD gel profile of each primer was scored across electrophoresis lanes as variables. Data were recorded as present (1) or absent (0) of band products from the gel electropherographs. The polymorphic data analysis followed Oyebola (2015). The generated binary data were used to estimate polymorphism level by dividing the polymorphic bands by the total number of scored bands.

$$\text{Percentage polymorphism} = \frac{\text{Number of polymorphic bands}}{\text{Total number of scored bands}} \times 100 \dots\dots\dots 4$$

Polymorphic Information Content (PIC) was calculated following Zhang, (2009) using the formula:

$$\text{PIC} = 2P_i (1 - P_i)$$

P_i = frequency of occurrence of polymorphic bands in different primers

Frequencies of allele and presence of private allele were observed and documented. Genetic differences from the generated data and dendrogram drawing was done following the methods of Ali *et al.* (2009).

Evolutionary analysis was done by Maximum Likelihood method. The evolutionary history was inferred by using the Maximum Likelihood method Tamura-Nei model Tamura K. and Nei M. (1993). The tree with the highest log likelihood (-262177.00) is shown. Initial tree(s) for the heuristic search were obtained automatically by applying Neighbor-Join and BioNJ algorithms to a matrix of pairwise distances estimated using the Tamura-Nei model, and then selecting the topology with superior log likelihood value. This analysis involved 12 nucleotide sequences. Codon positions included were 1st+2nd+3rd+Noncoding. There was a total of 23 positions in the final dataset. Evolutionary analyses were conducted in MEGA X [2]

RESULT AND DISCUSSION

Genetic Structure and Variability of Rapid Dna Markers

Attributes of the six selected RAPD Operon markers used in this study is presented in Table 1. Only one out of the six primers used did not amplify (**OPT-17**), the remaining five primers amplified. The studied individuals were fourteen in total, from two populations: the wild population (7 individuals) from Lamingo lake and the cultured or farmed population (7 individuals) from a farm.

The gel profiles of the studied samples showed that unique alleles were observed. A unique allele was observed in OPH-04 and OPH-08, and both unique alleles were specific for individual L3, (a member of the wild population from Lamingo lake). A unique allele was observed in OPT-01 and this was specific for individual F3, (a member of the farmed population). Two unique alleles were observed in OPT-08 and this was specific for individuals F2 and L4, (members of the farmed and wild populations respectively). All individuals were polymorphic at the 5th locus except individual L5 from the wild population.

Characteristics of selected primers used in this study is presented in Table 1. The table shows that RAPD primers were polymorphic and were able to detect private alleles in the population. A total of 602 individual bands were obtained from a total of 43 detected loci, which gave 38.4% polymorphism. Gene diversity ranged between 0.847 (OPT-08) to 0.918(OPH-04). Polymorphic Information Content (PIC) ranged between 0.829 (OPT-08) to 0.912(OPH-04).

Phylogenetic tree in Figure 1 was constructed from the scored bands of the primers presented using UPGMA and clustering all 14 samples of *C. gariepinus* into two main clades, with clade I consisting of 7 accessions (L1, L3, L4, L5, L6, L7 and F5) meanwhile, an outgroup (L3) was observed within the clade. Clade II also consist of 7 accessions (F1, F2, F3, F4, F6, F7 and L2). Within the wild samples and cultured samples, there are slight admixture. This is a pointer that cultured fish may be escaping into the wild and wild fish being used in culture systems, especially for breeding purposes Fish sample F5 was clustered along with other wild fish samples in clade I, while sample L2 was clustered along with other farmed or cultured fish samples in clade II. 85.71% of L samples clustered and diverged from 85.71% of F samples.

Intrapopulation Structure and Variability

Result of genetic structure and variability within each population is presented. A total of 301 individual bands were obtained from a total of 43 detected loci in the population of the farmed fish, which gave 35% polymorphism. While a total of 301 individual bands were obtained from a total of 43 detected loci in the population of the wild fish, which gave 38.9% polymorphism. This revealed that the wild population is more polymorphic than the farmed population in this study.

Relationship/Linkage of the Culture and Wild Populations

The phylogenetic tree in Figure 1 showed that F5 is more related to L1 and L7 than L3. L3 is an outgroup which has more ancestral traits than the rest of the L samples except L2 which is closest to L3 among all the L samples this means it is more distantly related.

Table 2: Polymorphic RAPD operon primers in *C. gariepinus*: code, and sequence information of the amplified products

Marker	Allele Frequency	Sample Size	No of Allele	Availability	Gene Diversity	PIC
H04	0.143	14.000	13.000	1.000	0.918	0.912
H08	0.143	14.000	12.000	1.000	0.908	0.901
T01	0.214	14.000	11.000	1.000	0.888	0.878
T02	0.214	14.000	10.000	1.000	0.867	0.854
T08	0.214	14.000	8.000	1.000	0.847	0.829
Mean	0.186	14.000	10.800	1.000	0.886	0.875

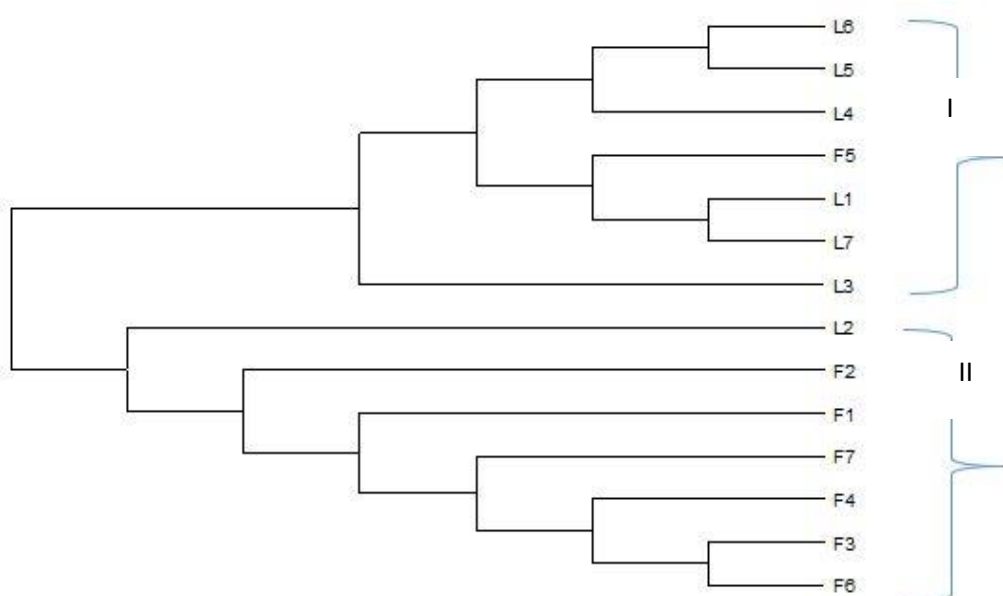


Figure 2: Unweighted Pair-group Method with Arithmetic Means tree (UPGMA) of wild and culture. L3 is an outgroup of Clade I.

Genetic structure and variability of *C. gariepinus* populations in culture and wild environment

Polymorphic information content of a marker measures the marker usefulness in linkage analysis. PIC greater than 0.5 is regarded as high (Elston, 2005). In this study the PIC of all the primers used were higher than 0.5 (0.829 – 0.912). This shows that the marker was very informative and confirm the efficiency of RAPD marker in estimating genetic diversity.

Gene diversity

The extent of gene flow in populations determines their potential for genetic diversity which is an important phenomenon in evolution and species survival. Culture and wild fish in Nigeria are continually admixing and thus reducing the genetic purity of endemic fish species (Oyebola and Fada, 2020)

In this present study, the cultured population showed a lower level percentage polymorphism (35% polymorphism) than the wild (38.9% polymorphism). This is similar to the findings of (Ikpeme *et al.*, 2016)

in Calabar and contrary to (Awodiran and Afolabi, 2018), where percentage polymorphism for cultured fish was higher (60%) and lower for the wild population (47.9%) in southwestern Nigeria.

Low genetic diversity is an index to low vigour and fitness in a population. This was revealed by indicators such as the percentage of polymorphic loci (%P) and other parameters. Low variation in *C. gariepinus* may be indicative to low survival and growth rate of cultured fish in Plateau state, Nigeria. This study showed that polymorphism in cultured and wild populations is low when compared to (Diyaware *et al.* 2018) which was 100% polymorphism using microsatellite marker.

Similar to (Oyebola, 2015), although with different primers, private alleles were seen. Using OPH-04 and OPH-08 there was presence of private alleles on individual L3. This signifies that a combination of the primers OPH-04 and OPH-08 can be used to identify samples with similar genetic traits as L3. The UPGMA dendrogram showed individual L3 to be an out group and has more ancestral traits when compared with other individuals within the clad I which is a clad of 85.71% wild *C. gariepinus*. The only individual closest to L3 (in terms of ancestral traits) on the UPGMA dendrogram is L2. Hence the combination of the two primers can be used as a marker for ancestral traits of native *C. gariepinus*. Other private alleles were seen using primer OPT-08, on individual L4 and F2, a wild and cultured fish respectively. Each band occurred on different loci.

CONCLUSION

There is an obvious admixture going on between the cultured and wild *C. gariepinus* and a resultant decreasing purity of genetic content of wild *C. gariepinus*.

The primer OPT-08 may be used preliminarily then OPH-04 and OPH-08 can then be used to make an inference on canonical differentiation of wild and culture *C. gariepinus*. This shows the usefulness and efficiency of the RAPD marker in the genetic studies of *C. gariepinus* as discussed by Ali *et al.*, (2009).

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COMPARATIVE GROWTH PERFORMANCE STUDIES OF HORMONAL SEX REVERSED, YY- SUPER MALE OFFSPRINGS AND MIXED SEX *Oreochromis niloticus*

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Introduction

Tilapia has now become a popular protein source to the poor, and also increasingly to middle class people. It serves as a typical model of a success story of farming outside its native area. Annual tilapia production was only 1.5 tons in 1950 which surpassed 1.5 million tons in 2002; increased by 1 million fold. Now it has surpassed even 3 million tons in 2010. Its production will still continue to grow exponentially, if high quality fry are readily available especially in countries like China where fry demand is in billions. How to produce and supply such a huge quantity of high quality tilapia fry has been a question for the countries which have potential to expand tilapia farming for domestic consumption and export markets.

Tilapia is one of the most important fish in aquaculture; tilapias are a group of “Cichlid” fish native to African countries. *Oreochromis niloticus* has been recognized as the prime domesticated species for farming (ICLARM 1991). The culture of tilapia is still beset with problems of their prolific breeding habit and stunted growth. The commonly farmed mouth-brooding tilapias are normally highly prolific. This might sound like a good thing for a farmer, but it can actually turn into a serious problem. Space and food are both limited resources, forcing adult fish to compete with fry and fingerlings leading to a reduced growth rate or even stunting. Numerous solutions to the problem have been proposed including manual sexing and separation of the sexes, culture in cages, controlled use of predator species, production of monosex hybrids, and direct hormonal sex reversal (Mair and Little, 1991). The latter two technologies of hybridization and sex reversal have become the most widely used and are successfully applied by many farmers. Today, commercial production of all-male tilapia is more commonly achieved through hormonal sex reversal and techniques have been developed and described for conducting this on a commercial scale (Guerrero and Guerrero, 1988; Popma and Green, 1990).

Although the growth performance of *Oreochromis niloticus* is highly influenced by genetics, quality and quantity of food, stock management and environmental factors (El-sayad, 2006), sex-specific differences in the growth of *Oreochromis niloticus* is apparent (Green *et.al*, 2007). Males grow bigger than females when it comes to tilapia and are therefore normally the sex of choice for mono-sex cultures. Most farmers choose to raise male tilapia only, since male tilapias grow bigger than the females. This has placed a demand on the fish breeding industry to produce mono-sex tilapia, i.e. males’ only groups that can be sold to farmers.

A few studies have demonstrated the enhanced yield of monosex male populations created by hybridization, sex reversal and manual sexing (McAndrew and Majumdar, 1989; Vera Cruz and Mair, 1994) under experimental condition. In an evaluation of growth of *O. niloticus* raised in earthen ponds (Macintosh *et al.*, 1988), mean harvest body weight and survival of sex reversed male populations (91.1%) were respectively 22.7% and 2.9% greater than for mixed sex controls (54.5% male), although neither of these values were significantly different.

The study aimed to evaluate the comparative growth performance of hormonal sex reversed, YY-males offspring and mixed sex of *Oreochromis niloticus*.

Materials and methods

Origin of stocks: The hormone sex reversed, YY-males offspring and mixed sex of *Oreochromis niloticus* fingerlings used for this study were produced at the Biotechnology Research Laboratory, National Institute for Freshwater Fisheries Research, New Bussa, Niger State, Nigeria where this study was also conducted.

Stocking of Fish Fingerlings: Sixty (60) fingerlings each of all-male hormone treated, YY-male offsprings and mixed sex of *Oreochromis niloticus* were stocked in duplicate in concrete tank measuring 2x2x1m³.

Feeds and Feeding: Feeding of fish fingerlings commenced immediately after stocking. The fish were fed with 35% crude protein feed at 5% body weight twice daily. The feed formulated from local feed ingredients was produced by NIFFR. Length and weight measurements and survival of the experimental fish were taken fortnightly. The experiment was monitored for six months.

Data analysis: The data obtained were subjected to Analysis of Variance (ANOVA) and where significant difference was observed means were separated using Duncan's Multiple Range Test with SPSS by setting type-one error at 5% level of significance and Microsoft Excel was used for plotting the graph.

Results and Discussion

Results of the growth performance and survival rate of hormone sex reversed, YY-male offsprings and mixed sex population of *Oreochromis niloticus* fingerlings are presented in Table 1. Figure 5 further shows the weight performance. However, figure 1 to 4 also shows the pictorial presentation of the samples.

The variations observed in growth performance and percentage survival among hormone sex reversed, YY-male offsprings and mixed sex population of *Oreochromis niloticus* fingerlings reared under the same conditions for six months were significantly different ($P < 0.05$) as shown in Table 1. The fish attained an average weight of 20.17g, 24.37g and 17.43g for hormone sex reversed, YY-males offspring and mixed populations respectively. The length difference for the hormone sex reversed (10.72) cm, YY-males offspring (11.58) cm and (10.46) cm for the mixed populations respectively. While the survival rates were 97.50%, 97.50% and 98.33% for hormone sex reversed, YY-males offspring and mixed sex population respectively.

Based on the data obtained, the water quality parameters; temperature, dissolved oxygen and Ph. measured during the study period were all within the optimum range for rearing tilapia (Boyd and Tucker, 1992; Xu *et.al*, 2005; Azaza *et.al*, 2008).



Fig.1: Hormone sex reversed



Fig.2: YY-males offspring



Fig.3: Mixed population
population



Fig.4: Eggs from the mixed

Table 1: The growth performance of hormone sex reversed, YY-males offspring and mixed sex population of *Oreochromis niloticus* fingerlings reared for six months

Growth Parameters	Hormone treated (HT)	Super male Offspring (YY)	Mixed Population (MX)
Initial Weight (g)	3.91 ± 0.37^a	4.50 ± 0.47^a	3.67 ± 0.71^a
Initial Length (cm)	5.24 ± 0.40^a	5.91 ± 0.27^a	5.78 ± 0.35^a
Final Weight (g)	20.17 ± 0.24^a	24.37 ± 0.90^b	17.43 ± 1.46^a
Final Length (cm)	10.72 ± 0.07^a	11.58 ± 0.49^a	10.46 ± 0.46^a
Total Weight Gain (g)	16.27 ± 0.62^a	19.87 ± 1.36^b	13.76 ± 0.76^a
Average Growth Rate (g/mth)	3.36 ± 0.04^a	4.07 ± 0.15^b	2.91 ± 0.25^a
Survival Rate (%)	97.50%	97.50%	98.33%

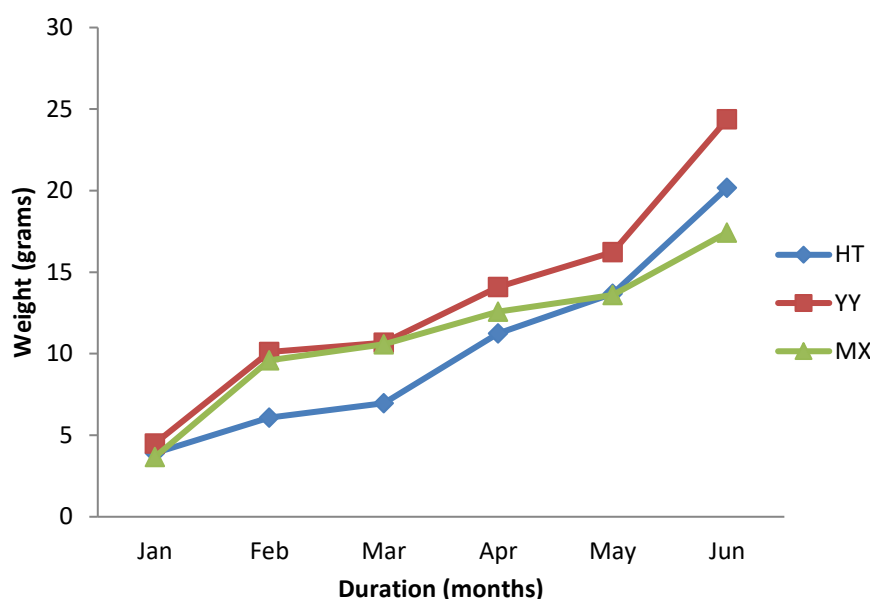


Fig. 5: The weight performance of hormone sex reversed, YY-males offspring and mixed sex population of *Oreochromis niloticus* fingerlings reared for six months.

The result of the present study shows significant difference between hormone sex reversed, YY-males offspring and mixed sex population of *Oreochromis niloticus*. However, the offsprings of YY-super male gave the best growth performance. This result can be considered a somewhat surprising as the YY- male technology has originally been proposed merely as an alternative method to produce all- or nearly all- male populations and not as a means to produce better performing all-male tilapia (Mair *et al.*, 1995). The hormone sex reversed gave the least growth performance at the initial stage of the experiment (January to May), but from the month of May they had better growth performance than the mixed population. This may be due to the fact that the initial hormone treatment to induce sex reversal may have a long term deleterious effect on the growth of treated fish as has been suggested in carp (Komen *et al.*, 1993). The mixed population that initially performed better than the hormone treated, began to decline in growth from the month of April as observed in figure 1. This may be due to the problem of their prolific breeding habit which results into stunted growth; fry and embryo were seen during sampling. Pandian and Sheela, (1999), Green *et.al*, (1997) and Chakraborty *et.al*, (2011) reported that all male tilapia showed superior growth rate over the females and mixed populations, this might be attributed to sex-specific growth ability, female mouth brooding behaviour or the efficient feeding habits of males. All male tilapia populations are often preferred, as they are generally known to grow faster than the female (Pandian and Varadaraj, 1990).

Conclusion

The result shows significant difference between hormone sex reversed, YY-males offspring and mixed sex population of *Oreochromis niloticus*. It can be concluded based on this study that the YY-offspring could be promising considering the fact that it gave the best growth performance.

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THE USE OF MOLECULAR MARKERS IN IDENTIFICATION OF FISH SPECIES THAT CAN EASILY ADAPT TO CLIMATE CHANGE: REVIEW

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ABSTRACT

This paper review molecular markers can be useful resources for identification of some fish species in several ways; it is recognized that all organisms are subject to mutations because of normal cellular operations or interactions with the environment leading to genetic variation (polymorphism). Genetic variation in species enhances the capability of organism to adapt to changing environment and it is necessary for the survival of the species. As climate change increases, disease severity and other incidences increases as well as water temperatures which affects fish physiological processes, spawning and survival of the juveniles. Molecular genetic markers are powerful tools to detect genetic uniqueness of individuals, populations or species, these markers have revolutionized the analytical power necessary to explore the genetic diversity.

Keywords: Climate Change, Molecular Markers, Aquatic organisms, polymorphism, Genetics.

INTRODUCTION

Molecular markers also known as genetic markers are fragments of DNA that are associated with certain location within the genome. Molecular markers are used in molecular biology and biotechnology to identify a sequence of DNA in a pool of unknown species (<https://en.m.wikipedia.org>). Molecular makers facilitate the identification of cryptic species and species with few identifiable phenotypic characteristics. The presumed neutrality of some molecular markers in conjunction with phylogenetic methods provides a new perspective on species identification, especially in hierarchical relatedness and relative rates of evolution. The increased frequency, with which cryptic species can be discovered with DNA sequence data, and often subsequently confirmed with morphological and ecological data, suggests that molecular data should be routinely incorporated into taxonomic research for easy identification of species that can be easily managed during severe climate change (Vito,A.M.F *et al* 2018).

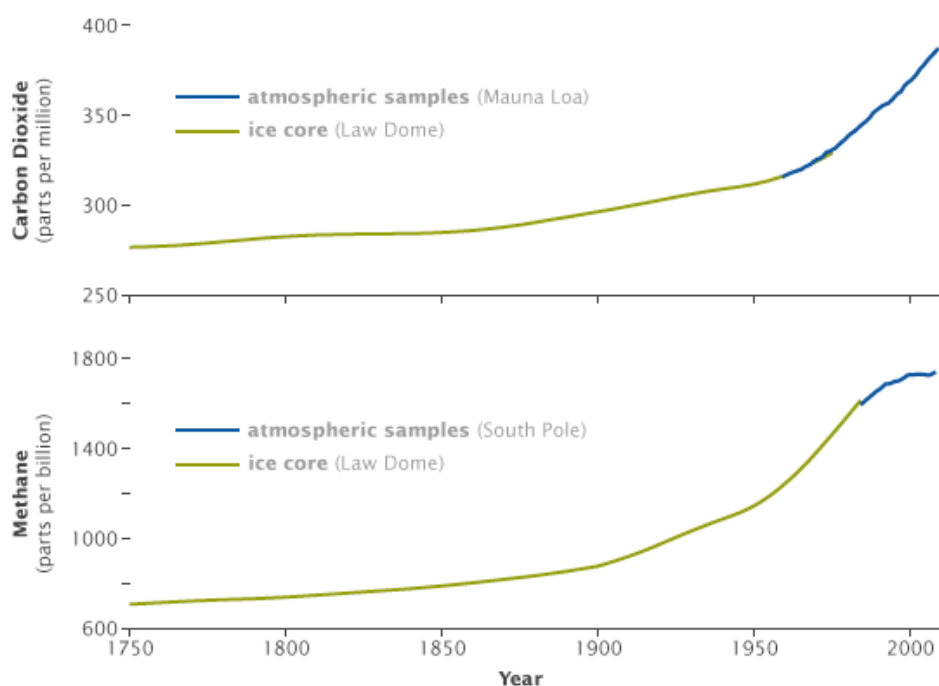
Climate change is the long term shifts in temperature and weather patterns, the shifts can be natural or artificial (Human activities) that produce heat trapping gases. The problem of climate change was identified as early as the nineteenth century, the issue did not appear on the international scientific and political agenda until the first World Climate Conference, held in 1979 (Gupta, 2010). Only in 1992, with the Rio Earth Summit, was an international instrument to address climate change adopted: the United Nations Framework Convention on Climate Change (UNFCCC). However it is now more certain than ever, that climate change is one of the defining issues of our time. Humans are changing Earth's climate. The atmosphere and oceans have warmed, which has been accompanied by sea level rise, a strong decline in Arctic sea ice, and other climate-related changes. The impacts of climate change on people and nature are increasingly apparent. Unprecedented flooding, heat waves, and wildfires have cost billions in damages. Habitats are undergoing rapid shifts in response to changing temperatures and precipitation patterns (Royal society, 2020).

Aquatic organisms are fragile and sensitive to a wide range of stressors. Reproduction, growth and population survival are highly dependent on water quality (Vito,A,M,F *et al.*, 2018). Climate change is no longer potential threat; it is rather an unavoidable occurrence. This is based on many lines of evidence in the present climatic parameters. The impacts of the accumulation of greenhouse gases in the atmosphere and water relate to the changes in the climatic parameters including gradual changes in water temperature, acidification of water bodies, changes in ocean currents and rising sea levels. These physical changes affect ecological functions within aquatic systems and the frequency, intensity and location of extreme weather events. A range of impacts on fisheries and aquaculture, both direct and indirect, can be expected (Onada and Ogunola, 2016).

In Nigeria, climate change have significant impacts on freshwater and marine aquatic systems hence affected many fish populations (Wilsey, *et al.*, 2013) and also resulted to global warming, sea level rise, change in ocean productivity, freshwater shortage and elevated water temperatures(P Sa-Lim *et al.*, 2017), these change affects fish physiological processes, thereby affecting spawning, survival of the juveniles. The impacts of increased flooding of the freshwater bodies has been negative through erosion of watershed, destruction of fish feeding and breeding habitats, decrease in primary productivity and alteration of the normal resilience of the aquatic systems, or positive in expansion of aquatic habitats for primary and fish productions especially during the dry season. Drought incidence draws down the lakes and reservoirs and gives rise to insufficient flow in the river basins for spawning and primary production thereby affecting fish production (Onada and Ogunola, 2016). It was also observed that rainfall in Nigeria has decreased by 92 mm and temperature increased by 0.8OC since 1960. This has led to increasing evapotranspiration and water stress resulting in the drying up of rivers and lakes. For example, Lake Chad has reduced in size from 22902 km² in 1963 to 16884 km² in 1972 and 304 km² in 2000.(Odjugo, 2009)

Causes of climate change

Climate can change due to natural processes (bio-geographical) and human activities (anthropogenic). The natural processes are the astronomical, the extraterrestrial factors and volcanic eruption (Anyadike, 2009) climate has always changed due to natural processes interacting with the sun such as water and energy cycles. In the past these changes were natural and caused by phenomena such as slow shift in the earth's orbit and change in solar and volcanic activities. However human activities has caused a sudden shift in the climate by releasing billions tone of carbon dioxide (CO₂) into the atmosphere and adding substantially to the greenhouse effect. Greenhouse emission have increased rapidly since the industrial revolution in the 1800's and reached its highest level in the decades of 2010s (IPCC 2014). Human activities has also emit large amount of chlorofluorocarbons (CFCs) and nitrous oxide (N₂O) among others into the atmosphere that depletes the ozone layer or activities that reduce the amount of carbons absorbed from the atmosphere. The human factors that emit large amounts of greenhouse gases include industrialization, burning of fossil fuel, gas flaring, urbanization and agriculture (Anyadike, 2009).



Source: ("Climate Change" graph done by Robert Simmon)

Impact of climate change on fisheries and aquaculture

The productivity of a fishery is tied to the health and functioning of the ecosystems on which it depends for food, habitat and even seed dispersal. The aquatic ecosystem is however extremely vulnerable to changes in primary production and the manner in which such production is transferred through the aquatic food chain. They are also vulnerable to changes in the physical and chemical parameters of the ecosystems, including temperature, salinity, acidity, and water levels and flows. The physical and chemical parameters are however directly responsible for the productivity and survivability of the biological organism which include fish and aquatic invertebrate. Because marine fish and aquatic invertebrates are cold blooded, their internal temperature varies with their environment. This makes them very sensitive to their environment. When changes do occur fish moves to areas where the external temperature allows them to regain their preferred internal temperature. This "behavioral thermoregulation" is resulting in rapid migrations into cooler bodies of water corresponding to the pole ward shift of climatic zones. Primary productivity is also affected by availability of nutrients in the marine environment, which in turn depends on freshwater run-off and ocean mixing as well as levels of light and temperature. With climate change, primary productivity is predicted to decline at lower latitudes where majority of the world's small-scale fisheries are located, reducing the productivity of the fisheries.

APPLICATION OF DEVELOPED MARKERS IN FISHERIES AND AQUACULTURE

Various type of DNA markers have been developed, including Allozymes, microsatellites, RAPDs, mt-DNA and SNPs. These markers in fish populations have revealed high levels of genetic variation distributed throughout the fish genome. A recent initiative has been made to accelerate efforts of DNA marker development, genome mapping and species identification, major progress has been made toward Expressed Sequence Tags (EST) and DNA barcode development in several aquaculture species. (Tanya and Kuhma, 2010). Fish can change it gene expression by switching on or off parts of the DNA that have specific function. These can also be turned up or down so that their function become stronger or weaker when necessary; this process is extremely quick and it can sometimes take place in few days which means certain species could be better equipped to deal with rapid changes in climate. (Kavya ,2016).

The inter-specific genetic divergence established through species specific diagnostic molecular markers provides precise knowledge on phylogenetic relationships and also resolve taxonomic ambiguities. These markers can be used to detect hybrid and introgressed or backcrossed individuals, distinguish early life history stage of morphologically close species both in hatchery and in natural populations. Species-specific allozyme markers have been identified in many fishes Tilapia, Anguilla species, Mugilidae species among

others. RAPD fingerprints were generated in several fish species and their taxonomic relationship has been analyzed. The RAPD-PCR technique was employed to identify three endemic morphologically similar Spanish species of *Barbus*: *Barbus bocagei*, *B. graellsii* and *B. sclateri* that have similar morphologies. RAPD markers were characterized to identify five species of family Cyprinidae: *Chondrostoma lemmingii*, *Leuciscus pyrenaicus*, *Barbus bocagei*, *Barbus comizo*, all endemic in the Iberian Peninsula, and introduced *Alburnus alburnus*, for studying genetic relationship and diversities in four species of Indian Major carps (family Cyprinidae): rohu (*Labeo rohita*), kalbasu (*L. calbasu*), catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*). Mt-DNA sequences have been used as useful marker for species-specific identification in many fishes (mtDNA) was examined to assess the genetic distinctiveness of the short-jaw cisco, *Coregonus zenithicus* and revealed high similarity of *C. zenithicus* and the related species *C. artedi*, *C. hoyi*, *C. kiyi*, and *C. clupeaformis*. Identification of *Astyanax altiparanae* (Teleostei, Characidae) in the Iguacu River, Brazil, was done on the basis of mitochondrial DNA and RAPD marker. Two species, *Acipenser baeri*, and *A. stellatus*, was studied using mitochondrial DNA (D-loop, cytochrome b (cyt-b) and ND5/6 genes) sequencing to determine whether traditionally defined subspecies correspond to taxonomic entities and conservation management units (Chauhan *et al.*, 2010).

Fifteen random primers were used to analyze the genome DNA of Jian carp (*Cyprinus carpio* var jian) by the RAPD technique. Study on cold tolerant traits for common carp *Cyprinus carpio* was conducted by Chang *et al* 2003. and nine RAPD-PCR markers associated with cold tolerance of common carp were identified. Genetic variation have been assessed using microsatellite genetic markers to identify the population structure of brook charr, *Salvelinus fontinalis* and 14 populations of northern pike (*Esox lucius*) in the North Central United States and in six populations from Quebec, Alaska, Siberia, and Finland. Based on five microsatellite loci, the genetic structure of endangered fish species *Anaocypris hispanica* was studied in eight distinct populations in the Portuguese Guadiana drainage to determine levels of genetic variation within and among populations and suggested implications for conservation of the species. Combination of allozyme and microsatellites was used to investigate genetic divergence in *Salmo trutta* and *Salmo salar*. Alarcon *et al.* represents population genetic analysis of gilthead sea bream (*Sparus aurata*) and Kanda, Kanda and Allendorf examine population genetic structure of bull trout *Salvelinus confluentus* using a combination of allozyme, microsatellite and mtDNA variation (Chauhan and Kumar, 2018).

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EFFECT OF AZANZA GARCKEANA ON THE EGG QUALITY OF CLARIAS GARIEPINUS OF TWO GENERATION

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ABSTRACT

The study evaluated the egg quality of African mud catfish *Clarias gariepinus* (Burchell 1822) fed treated *Azanza garckeana* pulp meal diets. Egg quality is significant for the production of high quality fish larva and for economical utilization of hatcheries (Coban *et al.*, 2011). The proximate composition was determined according to the association of Official Analytic Chemists (AOAC, 2010). Fish were randomly assigned to 12 per treatment with 3 replicates in a completely randomized design in concrete tanks as T1, T2, T3, T4 and T5. Sizes of the fishes range from 750 – 850g. The fish were fed with the experimental diet for 56 days at 5% body weight twice daily, morning and evening. Highest total number of eggs per 1gm was in T5 with 262. Highest egg diameter was recorded in T4 and T5 with 0.82 mm, the highest total weight of eggs was in T5 with 131.54 then followed by T4, T3 and T2 recorded 104.66, 89.10 respectively while T1 recorded to have the least with a value of 65.84. Highest total number of eggs was recorded in T5 with 16,777 then 15,765, 15,677 and 14,788 in T4, T2 and T2 respectively while the lowest is recorded in T1 with 14,344

Keywords. *Clarias gariepinus*, egg quality, *Azanza garckeana*

INTRODUCTION

Aquaculture refers to the breeding, rearing and harvesting of plants and animals of all types in aquatic environments including fresh and marine waters, Ponds, rivers, streams, lakes and oceans (Anene *et al.*, 2012). African catfish, *Clarias gariepinus*, is the most recent popularly cultured fish in Nigeria (Sogbesan and Ugwumba, 2006). This specie has drawn attention of aquaculturist because of its biological attributes that include fast growth rate, resistance to diseases, ability to tolerate a wide range of environmental parameters, resistant to handling and stress and possibility of high stocking density and also its highly adaptable and; can be artificially propagated by induced spawning techniques for reliable mass supply of fingerlings; commands a very high commercial value where it is highly cherished as food in Nigerian homes and hotels (Olaleye, 2005)

This fish shows a seasonal gonadal maturation which is usually associated with the rainy season. The maturation processes of *C. gariepinus* in nature are generally influenced by annual changes in water temperature and photoperiodicity and the final triggering of spawning is usually caused by a rise in water level due to rainfall (De Graaf *et al.*, 1995). The female African catfish has a fully developed ovary which contains "ripe" eggs all year round, if kept in ponds and water temperature kept above 22 °C. The eggs of a "ripe" female make up 15-20% of the body weight. (De Graaf *et al.*, 1995). In captivity the African Catfish does not spawn spontaneously since the environmental factors such as the rise in water level and inundation of shallow areas do not occur on the fish farms.

Egg quality is significant for the production of high quality fish larva and for economical utilization of hatcheries (Coban *et al.*, 2011). Egg generally plays an important role in the quality of the fish farming, good quality eggs increases fish production, all year round availability of fish, thereby increasing market demand for fish and fish protein, it also increases the revenue of the country and individuals directly involved in it. Ochoku *et al.*, 2015 reported that Fish feed nutrients for good quality egg includes protein (18-50%), lipid (10-25%), Carbohydrate (15-20%), ash (< 8.5%), phosphorus (< 1.5%), water (< 10%), and trace amounts of vitamins, and minerals. When fish are reared in high density indoor systems or confined in cages and cannot forage freely on natural feeds, they must be provided a complete diet.

Azanza garckeana popularly known as "morajwa" (African chewing gum) in Botswana, Azanza is widely known as tree hibiscus, snot apple, wild hibiscus (Orwa *et al.*, 2009) and "Goron Tula" in Northern

Nigeria (Gombe State). *Azanza garckeana* is a valuable edible indigenous fruit tree species. In Nigeria *A. garckeana* is found in Tula, Kaltungo Local Government Area of Gombe State

The selection of *Azanza garckeana* fruit as feed stuff ingredient is to add certain percentage inclusion based on desirable characteristics such as chemical composition, relative cheapness, abundance in supply and limited anti-nutritional factors. The need for high quality fish seed has necessitated research into various ways of improving egg quality and enhancing fertility of sperm in order to produce more fish as to meet the world protein demand

MATERIALS AND METHODS

Study Area

The study was conducted in the fish hatchery Department of Fisheries, Teaching and Research farm, Modibbo Adama University Yola, Adamawa State, Nigeria. Modibbo Adama University located on latitude 9.2°-9.33° longitude 12.3° – 12.50°E and an altitude of 185.9m, with an average annual rainfall of about 759mm with maximum temperature of 39.7°C. The wet season mostly starts from May through October, while the dry season runs through November and terminates in April. The driest months of the year are January and February when the relative humidity drops to 13% (Canback Global Income Distribution Database, 2014).

Experimental Design and Set-up.

Fish were randomly assigned to 12 per treatment with 3 replicates in a completely randomized design in concrete tanks as T1, T2, T3, T4 and T5. Sizes of the fishes range from 750 – 850g. The fish were fed with the experimental diet for 56 days at 5% body weight twice daily, morning and evening. At the end of brood stock treatment with the experimental diet for 56 days, a female brood stock was randomly collected from each treatment. They were used for artificial breeding and hatched the F1 generation.

Proximate composition of *Azanza garckeana*

The composition of *Azanza garckeana* was carried out in the department of fisheries, Modibbo Adama University, Adamawa state. The proximate composition was determined according to the association of Official Analytic Chemists (AOAC, 2010).

Induced Breeding

The selected brood stocks were kept separately in different tanks without feeding them, after they were injected 0.5 ml Ovaprim per kg weight and left for 10 – 12 hours latency period as a post ovulatory maturation period and to ensure high hatching rates and low proportion of deformed larvae, after the eggs had been stripped.

Collection of Eggs

Checking of ovulation usually starts 6 hours after injecting the fish with hormone and continued at one hour intervals. Females were tested for ovulation by hand stripping of the abdomen. The collection of eggs was done; the eggs were collected from each ovulated female through stripping by gently pressing the abdomen of the fish. The eggs were collected into clean bowls labeled according to the treatments.

RESULTS AND DISCUSSION

Proximate Percentage Composition of *Azanza garckeana* Pulp Meal in Experimental Diet.

The proximate percentage composition of *Azanza garckeana* pulp meal in experimental diet indicated highest of moisture in T3 with 11.70gm, Fats in T4 with 26gm, crude fibre in T5 with 7.5gm, Ash in T5 with 9.50gm and NFE in T2 with 18.00gm and ME cal/gm in T2 with 3,947.00.

Table 1: Proximate Percentage Composition of *Azanza garckeana* Pulp Meal in Experimental Diet.

Dietary Treatments	T1	T2	T3	T4	T5
Moisture content	10.2	8.7	11.7	9.6	9.6
Crude protein	40.0	40.0	40.0	40.0	40.0
Fat	24	24	25	26	27
Crude fibre	1.10	1.45	3.55	5.60	7.50
Ash	8.40	8.50	9.00	9.00	9.50
NFE	17.0	18.0	10.0	6.0	4.0
M. EKcal/g	3910.00	3947.00	3830.00	3840.00	3820.00

Nutrient Composition and percentage Dry Matter Basis of *Azanza garckeana* Pulp Meal

Table 2, showed the nutrient dry matter basis of *Azanzagarckeana* pulp meal, with highest was crude fibre with 40%, while lowest was fats with 7%. The dry matter was sodium highest with 182mg/l and lowest magnesium with 5mg/l

Table 2: Nutrient Composition and percentage Dry Matter Basis of *Azanzagarckeana* Pulp Meal

Nutrient and Mineral Composition	Values
Moisture content	14%
Crude Protein	12 %
Fat	7 %
Crude Fibre	40 %
Ash	11 %
NFE	16 %
Calcium	18mg/l
Iron	14mg/l
Sodium	182mg/l
Magnesium	5mg/l
Potassium	180mg/l
Phosphorus	60mg/l
PH	5
Ascorbic Acid	20mg/100g

Mean Egg Quality of *Clarias gariepinus* fed Different inclusion level of Processed *Azanza garckeana* Pulp meal for 1st filial generation.

Mean Egg Quality of *Claris gariepinus* fed Different inclusion level of Processed *Azanzagarckeana* Pulp meal for 1st Breeding presented in table 5, showed highest weight of fish in T5 with 76.00gm and length in T4 with 43.30cm. Highest total number of eggs per 1gm was in T5 with 262. Highest egg diameter was recorded in T4 and T5 with 0.82 mm, the highest total weight of eggs was in T5 with 131.54 then followed by T4, T3 and T2 recorded 104.66, 89.10 respectively while T1 recorded to have the least with a value of 65.84. Highest total number of eggs was recorded in T5 with 16,777 then 15,765, 15,677 and 14,788 in T4, T2 and T2 respectively while the lowest is recorded in T1 with 14,344.

Table 3: Mean Egg Quality of *Clarias gariepinus* fed Different inclusion level of Processed *Azanza garckeana* Pulp meal for 1st filial generation.

Parameter	T ₁	T ₂	T ₃	T ₄	T ₅
Weight of fish (g)	615	720	730	744	760
Length of fish (cm)	45.70	42.67	42.8	43.30	42.80
Total No. of eggs in 1g	245	260	250	260	262
Total weight of eggs (g)	65.84	65.98	89.10	104.66	131.54
Total No. of eggs	14,344	15,677	14,788	15,765	16,777
Egg diameter (mm)	0.70	0.78	0.78	0.82	40.82

Mean Egg Quality of F₁ *Clarias gariepinus* fed different Inclusion of Processed *Azanza garckeana* pulp meal.

Table 4 shows the fertilization and hatchability rate in percentages. The highest fertilization rate was 92% followed by 88%, 75%, 63%, and 40% in Treatment T5, T4, T3, T2 and T1 respectively. Treatment 5 had the best fertilization rate (92%) and the least with T1 with 40%, the unfertilized T1 with 60 and lowest in T5 with 08 %. Hatchability rate is higher in T5 with 96% then T1 has 93 then T2 and T4 with 92% each while T3 has the lowest with 84.

Table 4: Mean Egg Quality of F₁ *Clariasgariepinus* fed different Inclusion of Processed *Azanzagarckeana* pulp meal.

Parameters	T ₁	T ₂	T ₃	T ₄	T ₅
Weight of fish (g)	750 ^b	800 ^a	900 ^b	950 ^b	1140 ^b
Length of fish (cm)	39.50 ^d	42.70 ^b	48.00 ^a	48.30 ^c	48.70 ^b
Total number of eggs in 1g (g)	350 ^d	455 ^b	473 ^c	665 ^b	682 ^a
Total weight of egg (g)	22.85 ^b	71.03 ^c	125.1 ^a	130.82 ^c	142.28 ^a
Total number of eggs	7,980	32,441 ^b	59,125 ^b	20,495 ^c	95,670.96 ^a
Egg diameter (mm)	0.9 ^c	0.8 ^a	0.8 ^b	1.0 ^b	1.0 ^a

Percentage Proximate Composition of *Azanzagarckeana* Pulp Meal

The proximate composition of the processed *Azanzagarckeana* pulp meal fed *Clariasgariepinus* agreed with the findings of Craig *et al.* (2002) who reported that prepared diets may either be complete or supplemented, which supply all the ingredients necessary for optimal growth and health of the fish. The moisture content of the feed was in the range 9.6% to 11.7% which agree with the theoretical range of moisture content in all low moisture food (Bradley, 1994). None of the diets exceed 75%, and based on Crickenberger and Carawan (1996) who stated that a feed sample that does not exceed 75% moisture content are suitable to be utilized as foodstuffs for animals such as catfish. Therefore, *Azanzagarckeana* pulp meal diets can be classified as low moisture, biological material; meaning it is safe from biological spoilage and possible aflatoxin production by mould (Sogbesan and Ekundayo, 2014). Crude protein contents of the experimental diets in this study was 40% which is within the acceptable range of prepared feeds and is in agreement with the reports of Balogun *et al.* (2016). The crude lipid content of all the diets are within the range of 24%-27%, this values are within the acceptable standard lipid requirement for most tropical fishes (Adikwu, 2003). The crude fibre (CF) content of all the experimental diets ranged from 1.10%-7.50%, this disagree with Olomu (1995); that it is necessary to maintain fibre level at 3.5%-5% in the diets of animals. When dietary crude fibre exceeds 10-15% of the diet, it may depress feed intake because of excessive bulk and reduced palatability (Braude, 1967).

Reproductive Performance of *Clariasgariepinus* fed different Inclusion Levels of Processed *Azanzagarckeana* Pulp Meal

Furthermore, good egg quality are vital parameter in fish reproduction. The assessment of egg quality is very important and useful especially for diagnosing fertility performance in fish (Holtz and Forte, 1978). In this study, egg quality of fish fed varied inclusion levels of *Azanzagarckeana* Pulp Meal were influenced by the inclusion levels of the plant. The higher percentage of fertilized egg cells was observed in some fish fed processed *Azanzagarckeana* Pulp Meal diet. This is an indication that the influence of *Azanzagarckeana* Pulp Meal in increasing testosterone production in fish earlier reported in this work might have positively influenced egg quality.

CONCLUSION

The processed *A. garckeana* in the diets of *C. gariepinus* improved the reproductive performance of *C. gariepinus* broodstock. This could be used as a reliable ingredient for propagating *C. gariepinus* fingerling production. This study established the efficacy of *A. garckeana* as fertility enhancer in *C. gariepinus* broodstock and should be encouraged as it will minimize the dependence on synthetic drugs as fertility enhancing agents. *Azanzagarckeana* meal diet inputted in the diet of *C. gariepinus* has improved the egg of the fish. The highest inclusion gave the best result in gonad development, fertility and hatchability rate. It was observed that all fish fed processed experimental diet performed more than the control.

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EFFECT OF AZANZA GARCKEANA ON THE SPERM QUALITY OF CLARIASGARIEPINUS OF TWO GENERATION

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ABSTRACT

The study evaluated the sperm quality of African mud catfish *Clarias gariepinus* (Burchell 1822) fed treated *Azanza garckeana* pulp meal diets. Sperm quality is significant for the production of high quality fish larva and for economical utilization of hatcheries (Coban *et al.*, 2011). The proximate composition was determined according to the association of Official Analytic Chemists (AOAC, 2010). Fish were randomly assigned to 12 per treatment with 3 replicates in a completely randomized design in concrete tanks as T1, T2, T3, T4 and T5. Sizes of the fishes range from 750 – 850g. The fish were fed with the experimental diet for 56 days at 5% body weight twice daily, morning and evening. Treatment 5 has the highest active sperm with 55% followed by Treatment (T4) with 50% and least with Treatment 3 with 40 active sperm cell, the total number of motile sperm cell is recorded in Treatment 5 with 80 % then 75% in T4 then while T3 had the least active sperm of 64%. T3 had the highest number of sluggish sperm with a value of 30. Highest dead sperms are recorded in T1 with 36% while T5 had the least number of dead sperm of 20.

Keywords.: *Clarias gariepinus*, sperm quality, *Azanza garckeana*

INTRODUCTION

Sperm quality is significant for the production of high quality fish larva and for economical utilization of hatcheries (Coban *et al.*, 2011). Sperm generally plays an important role in the quality of the fish farming, good quality sperm increases fish production, all year round availability of fish, thereby increasing market demand for fish and fish protein, it also increases the revenue of the country and individuals directly involved in it.). Ochokwu *et al.*, 2015 reported that Fish feed nutrients for good quality egg and sperm includes protein (18-50%), lipid (10-25%), Carbohydrate (15-20%), ash (< 8.5%), phosphorus (< 1.5%), water (< 10%), and trace amounts of vitamins, and minerals. When fish are reared in high density indoor

systems or confined in cages and cannot forage freely on natural feeds, they must be provided a complete diet.

Azanza garckeana popularly known as “morajwa” (African chewing gum) in Botswana, *Azanza* is widely known as tree hibiscus, snot apple, wild hibiscus (Orwaet *al.*, 2009) and “Goron Tula” in Northern Nigeria (Gombe State). *Azanza garckeana* is a valuable edible indigenous fruit tree species. In Nigeria *A. garckeana* is found in Tula, Kaltungo Local Government Area of Gombe State. The selection of *Azanza garckeana* fruit as feed stuff ingredient is to add certain percentage inclusion based on desirable characteristics such as chemical composition, relative cheapness, abundance in supply and limited anti-nutritional factors

MATERIALS AND METHODS

Study Area

The study was conducted in the fish hatchery Department of Fisheries, Teaching and Research farm, Modibbo Adama University Yola, Adamawa State, Nigeria. Modibbo Adama University located on latitude 9.2⁰-9.33⁰ longitude 12.3⁰ – 12.50⁰E and an altitude of 185.9m, with an average annual rainfall of about 759mm with maximum temperature of 39.7⁰C. The wet season mostly starts from May through October, while the dry season runs through November and terminates in April. The driest months of the year are January and February when the relative humidity drops to 13% (Canback Global Income Distribution Database, 2014).

Experimental Design and Set-up.

Fish were randomly assigned to 12 per treatment with 3 replicates in a completely randomized design in a concrete tanks as T1, T2, T3, T4 and T5. Sizes of the fishes range from 750 – 850g.

The fish were fed with the experimental diet for 56 days at 5% body weight twice daily, morning and evening.

At the end of brood stock treatment with the experimental diet for 56 days, a male and female brood stock were randomly collected from each treatment. They were used for artificial breeding and hatched the F1 generation.

Proximate composition of *Azanza garckeana*

The composition of *Azanza garckeana* was carried out in the department of fisheries, Modibbo Adama University, Adamawa state. The proximate composition was determined according to the Association of Official Analytic Chemists (AOAC, 2010).

Induced Breeding

The selected brood stocks were kept separately indifferent tanks without feeding them, after they were injected 0.5 ml Ovaprim per kg weight and left for 10 – 12 hours latency period as a post ovulatory maturation period and to ensure high hatching rates and low proportion of deformed larvae, after the eggs had been striped.

Collection of Milt

Checking of ovulation usually starts 6 hours after injecting the fish with hormone and continued at one hour intervals. Milt were obtained by sacrificing the males. Each male was dissected carefully and their testes obtained. The milts were collected into clean bowls labeled according to the treatments.

Taking of Readings

Readings such as milt volume, weight and of right lobe, weight and of left lobe, sperm count, sperm motility (active, sluggish and dead) and total motile sperm were taken and recorded carefully

RESULTS AND DISCUSSION

Proximate Percentage Composition of *Azanzagarckeana* Pulp Meal in Experimental Diet.

The proximate percentage composition of *Azanzagarckeana* pulp meal in experimental diet indicated highest of moisture in T3 with 11.70gm, Fats in T4 with 26gm, crude fibre in T5 with 7.5gm, Ash in T5 with 9.50gm and NFE in T2 with 18.00gm and ME cal/gm in T2 with 3,947.00.

Table 1: Proximate Percentage Composition of *Azanzagarckeana* Pulp Meal in Experimental Diet.

Dietary Treatments	T1	T2	T3	T4	T5
Moisture content	10.2	8.7	11.7	9.6	9.6

Crude protein	40.0	40.0	40.0	40.0	40.0
Fat	24	24	25	26	27
Crude fibre	1.10	1.45	3.55	5.60	7.50
Ash	8.40	8.50	9.00	9.00	9.50
NFE	17.0	18.0	10.0	6.0	4.0
M. EKcak/g	3910.00	3947.00	3830.00	3840.00	3820.00

Nutrient Composition and percentage Dry Matter Basis of *Azanzagarckeana* Pulp Meal

Table 2, showed the nutrient dry matter basis of *Azanzagarckeana* pulp meal, with highest was crude fibre with 40%, while lowest was fats with 7%. The dry matter was sodium highest with 182mg/l and lowest magnesium with 5mg/l

Table 2: Nutrient Composition and percentage Dry Matter Basis of *Azanzagarckeana* Pulp Meal

Nutrient and Mineral Composition	Values
Moisture content	14%
Crude Protein	12 %
Fat	7 %
Crude Fibre	40 %
Ash	11 %
NFE	16 %
Calcium	18mg/l
Iron	14mg/l
Sodium	182mg/l
Magnesium	5mg/l
Potassium	180mg/l
Phosphorus	60mg/l
PH	5
Ascorbic Acid	20mg/100g

Mean Sperm Quality of *Clarias gariepinus* Fed Different Inclusion of processed *Azanza garckeana* pulp Meal

shows the mean sperm quality of catfish fed different inclusion level of processed *Azanza garckeana* pulp meal. treatment 5 has the highest active sperm with 55% followed by Treatment (T4) with 50% and least with Treatment 3 with 40 active sperm cell, the total number of motile sperm cell is recorded in Treatment 5 with 80 % then 75% in T4 then while T3 had the least active sperm of 64%. T3 had the highest number of sluggish sperm with a value of 30. Highest dead sperms are recorded in T1 with 36% while T5 had the least number of dead sperm of 20.

Table 3: Mean Sperm Quality of *Clarias gariepinus* Fed Different Inclusion of processed *Azanza garckeana* pulp Meal

Parameters	T1	T2	T3	T4	T5
Weight of fish (g)	800	815	815	820	825
Length of fish (cm)	55	57	57	58	58
Weight of right lobe (g)	1.55	2.30	2.40	2.50	2.55
Weight of left lobe (g)	1.35	2.80	2.89	2.90	2.77
Length of right lobe (cm)	5.30	5.50	6.20	7.30	7.44
Length of left lobe (cm)	5.20	5.45	6.00	7.00	7.20
Milt volume (mls)	3.20	4.50	5.70	6.10	7.20
Sperm count 10 ^{x6}	100	330	340	350	390
Sperm motility					
Active	45	45	40	50	55
Sluggish	19	25	30	25	25
Dead	36	30	30	25	20
Total motile sperm (TMS)	64	70	70	75	80

Keys: T1: (Control basal diet) without processed *Azanza garckeana* pulp meal, T2: Processed *Azanzagarckeana* pulp meal at 50g/kg, T3: Processed *Azanza garckeana* pulp meal at 100g/kg, T4: Processed *Azanza garckeana* pulp meal at 150g/kg, T5: Processed *Azanza garckeana* pulp meal at 200g/kg

Mean Sperm Quality of F1 *Clarias gariepinus* Fed with different Inclusion of Processed *Azanza garckeana* pulp meal for 2nd Breeding.

The mean sperm quality of catfish fed different inclusion level of processed *Azanza garckeana* pulp meal is shown in Table 14. Treatment 5 has the highest active sperms with 80 followed by T4 having 70 while T1 has the least active sperms. T2 has the highest sluggish sperms with the value 25 while T5 has the lowest sluggish sperms with 15. T1 has highest dead rate of sperms cell with 40 while T5 has the lowest with 05. The total motile sperm of 95 was the highest which was from T5 and T4 while other Treatments T2, T3 and T1 has 85, 80 and 60 respectively.

Mean Sperm Quality of F1 *Clarias gariepinus* fed different Inclusion of *Azanza garckeana* pulp meal For 2nd Breeding

Parameters	T1	T2	T3	T4	T5
Weight of fish (g)	800 ^c	900 ^a	550 ^c	700 ^b	850 ^c
Length of fish (cm)	46.7 ^b	45.2 ^a	48.5 ^b	47.5 ^a	54.0 ^c
Weight of right lobe (g)	1.59 ^d	2.50 ^b	2.30 ^c	2.80 ^a	2.42 ^b
Weight of left lobe (g)	1.40 ^d	2.85 ^b	2.90 ^a	2.44 ^c	2.90 ^a
Length of right lobe (cm)	5.00 ^a	5.00 ^a	3.89 ^c	4.00 ^c	4.2 ^b
Length of left lobe (cm)	4.5 ^b	4.9 ^a	4.3 ^c	4.00 ^d	4.22 ^c
Milt volume (mls)	1.82 ^b	3.30 ^b	3.10 ^c	3.40 ^b	3.60 ^a
Sperm count 10 ⁶	110 ^d	340 ^c	341 ^c	352 ^b	394 ^a
Sperm motility					
Active	40 ^b	60 ^a	60 ^a	70 ^c	80 ^b
Sluggish	20 ^b	25 ^b	20 ^c	20 ^a	15 ^b
Dead	40 ^a	15 ^b	20 ^a	15 ^a	05 ^a
Total Motile Sperm (TMS)	60 ^b	85 ^a	80 ^b	95 ^b	95

Means of Data on the same row with different superscript are significantly different ($p < 0.05$).

Percentage Proximate Composition of *Azanza garckeana* Pulp Meal

The proximate composition of the processed *Azanza garckeana* pulp meal fed *Clarias gariepinus* agreed with the findings of Craig *et al.* (2002) who reported that prepared diets may either be complete or supplemented, which supply all the ingredients necessary for optimal growth and health of the fish. The moisture content of the feed was in the range 9.6% to 11.7% which agree with the theoretical range of moisture content in all low moisture food (Bradley, 1994). None of the diets exceed 75%, and based on Crickenberger and Carawan (1996) who stated that a feed sample that does not exceed 75% moisture content are suitable to be utilized as foodstuffs for animals such as catfish. Therefore, *Azanza garckeana* pulp meal diets can be classified as low moisture, biological material; meaning it is safe from biological spoilage and possible aflatoxin production by mould (Sogbesan and Ekundayo, 2014). Crude protein contents of the experimental diets in this study was 40% which is within the acceptable range of prepared feeds and is in agreement with the reports of Balogun *et al.* (2016). The crude lipid content of all the diets are within the range of 24%-27%, this values are within the acceptable standard lipid requirement for most tropical fishes (Adikwu, 2003). The crude fibre (CF) content of all the experimental diets ranged from 1.10%-7.50%, this disagree with Olomu (1995); that it is necessary to maintain fibre level at 3.5%-5% in the diets of animals. When dietary crude fibre exceeds 10-15% of the diet, it may depress feed intake because of excessive bulk and reduced palatability (Braude, 1967).

Reproductive Performance of *Clarias gariepinus* fed different Inclusion Levels of Processed *Azanza garckeana* Pulp Meal

The fish fed with *Azanza garckeana* Pulp Meal showed high active sperm motility value compared to the control, and also in the aspect of egg quality. It was observed that there was an improvement in the fertilization and hatchability rate from F₂ when compared to the breeding done with the F₁ fed with *Azanza garckeana* Pulp Meal inoculated feed. This agrees with the study of Sahoo *et al.*, (2003) which showed a significant improvement in the reproductive performance of the offspring (F₂) when compared with the parent's (F₁) reproductive performance. This showed that inclusion of *Azanza garckeana* Pulp Meal have more effect on the female reproductive performance compared to the males. In this study, the parent broodstock for first breeding tend to have the highest values in milt volume and sperm count when compared

to the breeders for the 2nd breeding, this disagrees with the study of Sahoo *et al.*, (2003) that observed a significant increase in the reproductive performance and quality of the male broodstock fed with formulated feed inoculated with plant based supplements.

The higher percentage of total motile sperm cells was observed in some fish fed processed *Azanza garckeana* Pulp Meal diet. This is an indication of the viability of sperm cells with possibly higher fertilizing capacity. The values for sperm concentration in this study is higher than what was reported by Abu *et al.* (2013) that fed varied dietary levels of *Moringa oleifera* leaf meal. This is an indication that the influence of *Azanza garckeana* Pulp Meal in increasing testosterone production in fish earlier reported in this work might have positively influenced sperm quality, and egg quality. Testosterone is the major androgen secreted by the male gonad. It plays an essential role in the development of the normal male and maintenance of many male characteristics including muscle mass and strength, bone mass, libido, potency and spermatogenesis (Sanniet *et al.*, 2012). These are essential attributes that can enhance the ability of a fish to successfully produce viable sperm cells. Ebonget *et al.*, (2014) reported that *Moringaoleifera* extract normalized the levels of serum testosterone.

CONCLUSION

The processed *A. garckeana* in the diets of *C. gariepinus* improved the reproductive performance of *C. gariepinus* broodstock. This could be used as a reliable ingredient for propagating *C. gariepinus* fingerling production. This study established the efficacy of *A. garckeana* as fertility enhancer in *C. gariepinus* broodstock and should be encouraged as it will minimize the dependence on synthetic drugs as fertility enhancing agents. *Azanza garckeana* meal diet imputed in the diet of *C. gariepinus* has improved sperm quality of the fish. The highest inclusion gave the best result in gonad development, fertility and hatchability rate. It was observed that all fish fed processed experimental diet performed more than the control.

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EFFECT OF AFRICAN FAN PALM (*BORASSUS AETHIOPUM*) MEAL ON MILT QUALITY OF *CLARIAS GARIEPINUS* BROODSTOCK.

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ABSTRACT

The effect of processed African Fan Palm Meal (AFPM) on the reproductive indices of *Clarias gariepinus* brood stock was evaluated. Results from phytochemical analysis of AFPM showed that steroid had 0.94g/mg, Saponin 1.20g/mg, Tanin 0.88g/mg, Anthraquinones 0.52g/mg, Flavonoids 0.52g/mg, Oxalate 0.30g/mg. The fish were fed for 56 days. The results revealed that the fish fed with diet having 2.0g/kg (D5) of AFPM had the highest milt volume of 3.73ml when compared to D1(1.7) D2(3.5) D3(3.47) D4(3.55). In the weight gain of testes, D5 had the highest weight of right lobe (4.75g) and left lobe (2.92g). The sperm quality of F1 brood stock fed different inclusion levels showed that the total motile sperm (TMS) was highest in D₂ (70), while the other treatments had 60 each. Milt volume was highest in D5 (3.60ml), followed by D4 (3.40ml), D2 (3.30ml) while the least was in D1 (1.80ml). The sperm count increased with increasing inclusion levels. D5 had the highest sperm count (394×10^6).

KEYWORDS; Milt Quality, *Clarias gariepinus* Broodstock. African Fan Palm (*Borassus aethiopum*) Meal.

Introduction

The African Catfish *C. gariepinus* and *C. anguillaris* have been recently investigated as a potential aquaculture species (Hussein, 2012); the *Clariids* constitute an excellent food fish of high commercial value. It is very important for sustainability of aquaculture industry in Nigeria (Owodeinde and Ndimele, 2011). Aquaculture production is for a great part dependent on some supplementary or external feed, including fishmeal. African fan palm (*Borassus aethiopum*) is a member of the family *Arecaceae* and grows in the wild across Africa. The fan palm bears fruits massively (between 50-150 fruits per tree) in every 8 months (Ali *et al.*, 2010; Ouinsavi *et al.*, 2011). However, only about 30-40% of these available nutritious fruits are utilized as food (Ali *et al.*, 2010; Siaw *et al.*, 2014). The remaining 60 to 70% undergo losses via microbial decomposition. Losses of the African fan palm fruits greatly results from limited diversification of utilization as well as poor storage conditions. African fan palm fruit pulp as an accompaniment to foods is known to impart natural sweetness, aroma, and color (Adzinyo *et al.*, 2015). Fresh African fan palm fruit pulp is a rich source of minerals, fiber, sugars, vitamin A, vitamin C and moisture (Ali *et al.*, 2010).

MATERIALS AND METHODS

This research experiment was conducted at the Teaching and Research farm, Department of Fisheries, Modibbo Adama University of Technology Yola, Adamawa state, Nigeria. Adamawa State is located at the North Eastern part of Nigeria. It lies between latitude 7° and 11° N of the equator and between longitude 11° and 14° E of the Greenwich meridian. It shares boundary with Taraba State in the South and West, Gombe State in its Northwest and Borno State to the North. Adamawa State has an international boundary with the Cameroon Republic along its eastern boarder. The State covers a land area of about 38,741 km². It is divided

into 21 local Government Areas (Mohammed, 2020). It has a population of 3,168,101 (National Bureau for Statistics, 2007).

Experimental Set up

A total of 60 matured males and gravid females' catfish (*C. gariepinus*) were purchased from Abdulfana fish farm Yola south LGA, Adamawa state with the same age of 7 months and average weight of 850g. They were acclimatized and fed commercial feed for 7 days. The fish were randomly assigned to 12 fish per treatment with 3 replicate in a Completely Randomized Design in a concrete pond of size 3 by 4 by 1m. The fish were starved for 24 hours prior to commencement of the trial to allow utter digestion of any food in their stomach. In second trail after hatching the fish were reared for the period of 60 days and fed with commercial feed. A total of 60 fish were then selected at random with 12 fish from each treatment and stocked to each of the treatment tanks. Five isonitrogenous diets (D1, D2, D3, D4 and D5) were formulated from practical ingredients based on the formulation defined for African Catfish (*C. gariepinus*) Fagbenro and Adebayo (2005). The control (D1) basal diet was without processed African fan palm meal and the others had the following inclusion level of African Fan Palm Meal (PAFPM) at 0.5g, 1.0g, 1.5g, and 2.0g/kg respectively. The experimental diets were formulated to contain 35% crude protein. The experimental diets were assigned randomly to the tanks and each group of fish was fed at 3% body weight twice per day for 56 days. Every week, all the fish were batch-weighted to determine the growth performance.

RESULTS AND DISCUSSION

The results revealed that the fish fed with diet having 2.0g/kg (D5) of AFPM had the highest milt volume of 3.73ml when compared to D1(1.7) D2(3.5) D3(3.47) D4(3.55). In the weight gain of testes, D5 had the highest weight of right lobe (4.75g) and left lobe (2.92g). The sperm quality of F1 broodstock fed different inclusion levels showed that the total motile sperm (TMS) was highest in D₂ (70), while the other treatments had 60 each. Milt volume was highest in D5 (3.60ml), followed by D4 (3.40ml), D2 (3.30ml) while the least was in D1 (1.80ml). The sperm count increased with increasing inclusion levels. D5 had the highest sperm count (394×10^6).

Table 1. Phytochemical Composition of African Fan Palm Meal

Phytochemical composition	Qualitative	Quantitative
Saponins	+++	1.20
Tannins	+	0.88
Steroids	++	0.94
Glycosides	—	—
Anthraquinones	+	0.52
Flavonoids	++	0.52
Oxalate	+	0.03

Table 2. Mean Sperm Quality of *Clarias gariepinus* fed different Inclusion Levels of Processed African Fan Palm Meal

Parameters	D1	D2	D3	D4	D5
Weight of fish (g)	808.3 ^c	951.67 ^a	853.33 ^{bc}	936.67 ^{ab}	863.33 ^b
Length of fish (cm)	48 ^b	50 ^{ab}	47.33 ^{bc}	51.33 ^a	47 ^{bc}
Weight of right lobe (g)	1.49 ^{bc}	2.41 ^b	2.42 ^b	2.50 ^a	2.47 ^{ab}
Weight of left lobe (g)	1.40 ^{bc}	2.85 ^{ab}	2.87 ^{ab}	2.72 ^b	2.92 ^a
Length of right lobe (cm)	5.00 ^a	5.00 ^a	4.73 ^{ab}	4.67 ^b	4.75 ^{ab}
Length of left lobe (cm)	5.17 ^a	5.00 ^a	4.20 ^{ab}	4.03 ^b	4.00 ^b
Milt volume (mls)	1.72 ^c	3.50 ^b	3.47 ^{bc}	3.55 ^{ab}	3.73 ^a

Sperm count 10 ^{x6}	110 ^c	340 ^{bc}	341 ^b	352 ^{ab}	394 ^a
Sperm motility					
Active	40 ^b	40 ^b	40 ^b	40 ^b	50 ^a
Sluggish	20 ^b	30 ^a	20 ^b	30 ^a	20 ^b
Dead	40 ^a	30 ^b	40 ^a	30 ^b	30 ^b
Total Motile Sperm (TMS)	60 ^b	70 ^a	60 ^b	70 ^a	70 ^a

Means of data on the same row with different superscript are significantly different (p<0.05).

In this study, sperm quality and egg quality of fish fed varied inclusion levels of African fan palm meal were influenced by the inclusion levels of the plant. The higher percentage of total motile sperm cells and fertilized egg cells was observed in some fish fed treated African fan palm meal diet. This is an indication of the viability of sperm cells with possibly higher fertilizing capacity. The values for sperm concentration in this study is higher than what was reported by Abu *et al.* (2013) that fed varied dietary levels of *Moringa oleifera* leaf meal. This is an indication that the influence of African fan palm meal in increasing testosterone production in fish earlier reported in this work might have positively influenced sperm quality, and egg quality.

Conclusion

2.0g/kg inclusion level of AFPM in feed of *Clarias gariepinus* gave the best performance in term of sperm quality, percentage fertilization and hatchability. Milt volume and sperm count increase all through during the study period. The study revealed that AFPM could be used as fertility enhancer in *C. gariepinus* brood stock and can reduced dependence in synthetic hormones if incorporated in fish diets.

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ABSTRACT

Mormyrids are among the most popular freshwater fish endemic to tropical Africa, where they play a significant role in the economy and food security of the region. Mormyridae harbours over 225 species classified into 22 genera; such great species diversity requires many systematics tools for unambiguous identification and classification. Cytogenetics data provides an additional technique for a better comprehension of species diversity and for discovering cryptic species. However, information on many mormyrids' karyotypes is unavailable, thus limiting its application in Mormyridae systematics. This study provides data on the karyotype of *Brienomyrus brachyistius* and *Hyperopisus bebe* from Oluwa and Osun Rivers, respectively. Chromosomes were extracted from the fish kidney following the conventional cytogenetic technique. The fish was subjected to an intra-peritoneal colchicine injection at 1ml per 100g of fish mass. Hypotonic treatment was in 0.56% KCl solution, and cells fixation and washes were in 3: 1 methanol: acetic acid. Slides preparation and staining followed standard Giemsa staining procedure. The karyomorphs of $2n = 50$ (50sta) and $2n = 40$ (24m+6sm+10st/a) obtained in *Brienomyrus brachyistius* and *Hyperopisus bebe*, respectively, in this study, differed from those reported in the literature; suggesting the presence of more species in these genera than has been reported.

Keywords: Cytogenetics, chromosomes, karyomorphs, karyotype, Mormyrids,

INTRODUCTION

Mormyrids constitute a large group of freshwater fish endemic to tropical Africa; they are found in all the main African river basins but absent in the Sahara, southernmost Cape Provinces and northernmost Maghreb (Roberts 1975). Mormyrids are of high economic interest as food and aquarium fish and are significant in the food security of riverine dwellers. In addition, mormyrids can generate weak electric signals and perceive similar signals from other fishes (Arnegard & Hopkins, 2003)). Mormyridae is classified into 22 genera and over 225 species, making it among the most speciose African freshwater fish families. The remarkable species diversity of Mormyrids requires a multi-prong approach for species identification and classification; to this end, morphological, osteological, molecular and electric organ discharge systems have been employed; resulting in the discovery of many cryptic species (Kramer & Wink, 2013; Sullivan *et al.*, 2016). In addition, the cytogenetic procedure provides an additional tool to comprehend better this group's species diversity (Jegade *et al.*, 2018; Cioffi *et al.*, 2018). However, the dearth of cytogenetic data has been a limiting factor to its application being available on less than 10% of mormyrids; and rarely more than two per genus (Simanovsky *et al.*, 2021a).

The genus *Hyperopisus* is mono-generic and is represented by *Hyperopisus bebe*; Simanovsky *et al.* (2021^a) provided the first cytogenetic data on the fish by analyzing the chromosome complement of the Alvero River population from Ethiopia. The species presents $2n = 40$, with 24 metacentrics (m), 2 submetacentric (sm), and 14 acrocentrics (a): $2n = 40$ (24m+2sm+14a).

Species of the genus *Brienomyrus* also known as baby whales in the aquarium pet trade owing to their resemblance to the sperm whale, consist of three species: *B. adustus*, *B. longianalis* and *B. brachyistius*: *B. longianalis* found in the coastal waters of Mali, Nigeria, Cameroon, Guinea, Niger and Sierra Leone, while *B. brachyistius* distribution stretches from the Gambia to the Democratic Republic of Congo, but *B. adustus* is endemic to the coastal waters of Cameroon (Bigorne, 1990; Froese & Pauly, 2022). Uyeno (1973) described the karyotype of *Marcusenius brachistius* (now *Brienomyrus brachyistius*) as $2n = 48$ (1m+4sm+43a), while Ozouf-Costaz (2015) recorded $2n = 50$ (2m+6sm+42a) for an unidentified *Brienomyrus* species from Ebeigne, Woleu River, Gabon. This study describes the basic karyotype of *Hyperopisus bebe* and *Brienomyrus brachyistius* from the Osun and Oluwa Rivers, respectively. The study suggests the presence of more species in the genera *Hyperopisus* and *Brienomyrus* than is presently known.

MATERIALS AND METHODS

Sample Collection

Five samples each of *Hyperopisus bebe* and *Brienomyrus brachyistius* (Figures 1 & 2) were procured at the fish landing sites of the local fishers hunting in the Asejire Reservoir (4.52°56'E, 7.5° 91' N), Osun River basin, Oyo State and Oluwa River, Okitipupa, Ondo State, Nigeria (4.79° 01'E, 6.51° 45'N). The rivers are located in the forest belt of southwestern Nigeria and discharge directly into the Nigerian coastal lagoon

system. After collection, the fish species were transported in aerated plastic containers and acclimatized for a day before the laboratory procedure. The experiment was done at the Department of Zoology, Obafemi Awolowo, University, Ile-Ife, but Silver nitrate banding was at the Fish Cytogenetic Laboratory, Department of Genetics and Evolution, Federal University of Sao Carlos, Brazil.

Metaphase Chromosomes Preparation

The chromosomes were prepared from the anterior portion of the fish kidney, as described in Bertolo *et al.* (2015). The fish was injected intraperitoneally with 0.5% colchicine solution for about 2 h and euthanized. Next, the anterior kidney was removed and transferred to a hypotonic solution containing 0.56% KCl at room temperature for 20 min. The kidney fragments were homogenized, followed by three subsequent washing in methanol: acetic acid (3:1). After the final centrifugation, the cells were re-suspended in 1 ml of the fixative solution. Howell and Black (1980) described the Silver nitrate banding technique used in the study. All the laboratory procedures followed standard cytogenetic techniques.

Slide Preparation and Karyotyping

Two drops of the chromosome preparation were dispensed on a pre-cleaned glass slide and dried on a hot plate. Then, the slide was stained with 6% Giemsa solution, and the excess stain was washed off and air-dried. The criteria described by Levan *et al.* (1968) were used to characterize and group the chromosomes into three categories: metacentric (m), submetacentric (sm), and acrocentrics (a). Homologous chromosomes were paired based on the size and position of the centromere of 15 metaphase spreads of three unsexed *H. bebe* and 35 metaphases of 5 *B. brachyistius*.



Figure 1: *Hyperopisus bebe* from Asejire Reservoir, Osun River basin, Nigeria



Figure 2. *Brienomyrus brachyistius* from Oluwa River, Nigeria.

RESULTS AND DISCUSSION

The most frequent diploid number in *H. bebe* was $2n = 40$ (Figure 3). The best metaphases were obtained in the Silver nitrate-stained nucleolar organizing region and were therefore used for the karyotyping. The chromosome complement consisted of 24 metacentrics, 6 submetacentric, and 10 acrocentrics, with a karyotype formula of $2n = 40: (24m+6sm+10st/a)$, $FN = 70$. The shorter arm of the largest metacentric chromosome (chromosome 1) harbours the nucleolar organizer regions in the interstitial portions of the chromosome pair (Figure 3). On the other hand, almost all the 35 metaphases obtained from the five specimens of *B. brachyistius* had a diploid number of $2n = 50$, displaying a karyotype composed of only acrocentrics with a karyotype formula of $2n = 50 (50 st/a)$, $FN = 50$. (Figure 4). No heteromorphic differentiated chromosome was observed in any of the metaphase spreads.

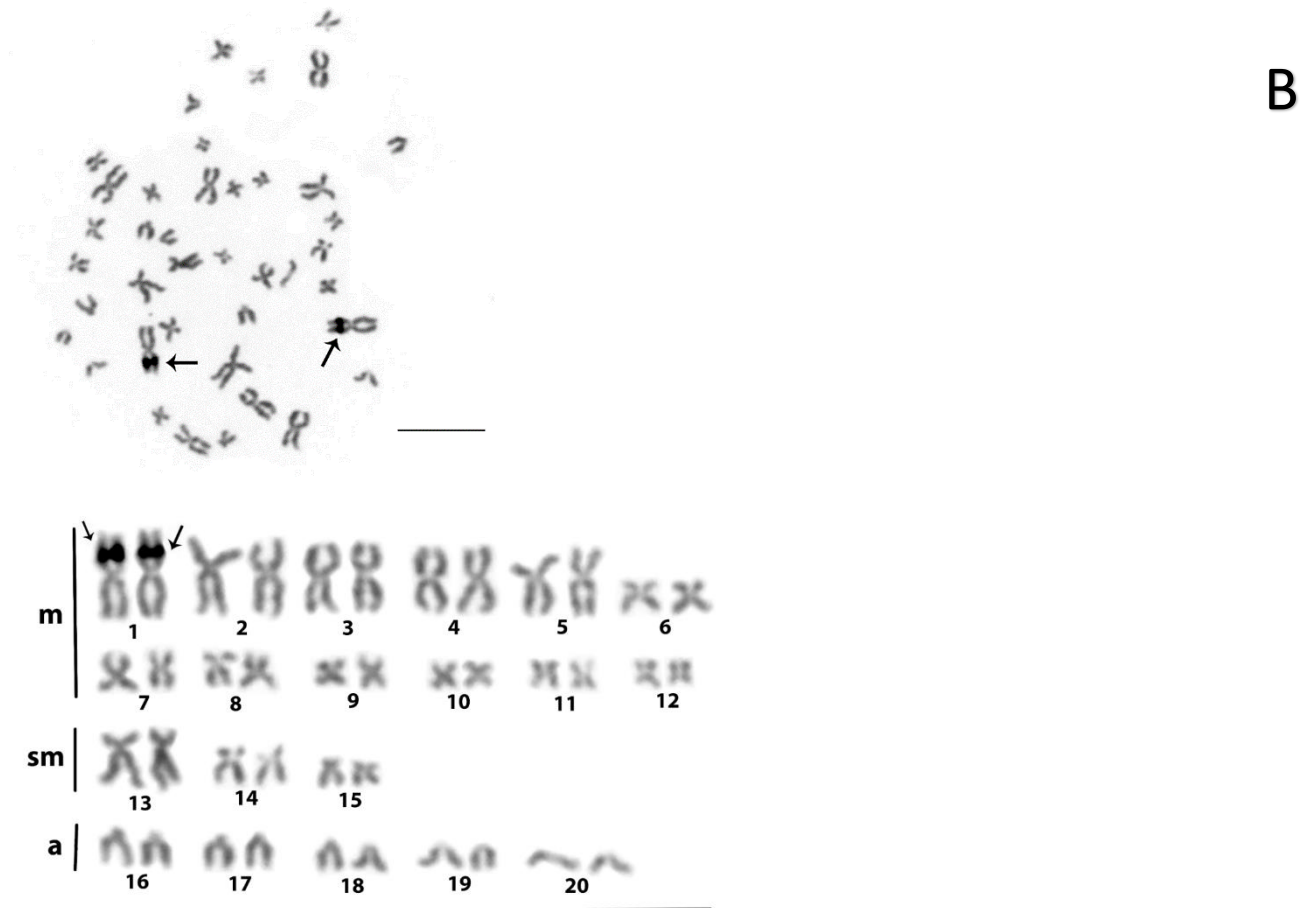


Figure 3: Karyotype of *Hyperopisus bebe* in Asejire Reservoir, Nigeria. A = Metaphase Spread, B = Karyogram, Bar = 5 μ ; arrows indicate nucleolar organizer region, Karyotype formula; $2n = 40$: (24m+6sm+10st/a), FN = 70.

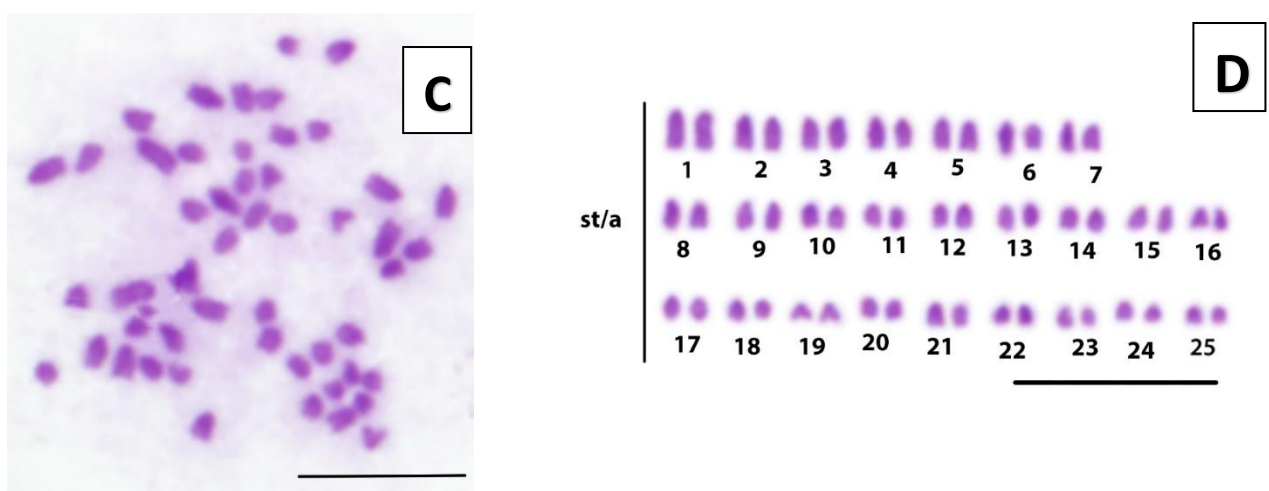


Figure 4: Karyotype of *Brienomyrus brachyistius* in Oluwa River, Nigeria. C = Metaphase Spread, D = Karyogram, Bar = 10 μ . Karyotype formula; $2n = 50$ (50 st/a), FN = 50

Hyperopisus bebe is considered the only species in the *Hyperopisus* genus; however, the karyotype of $2n = 40$ (24m+6sm+10a), FN = 70 recorded for the Asejire Reservoir population compared to its counterpart in

the Alvero River reported in Simanovsky *et al.* (2021a), as $2n = 40$: (24m+2sm+14st/a), FN = 66, implies the two populations represent distinct evolutionary lineages and two potential species. The Bebe karyotypes differ from the postulated $2n = 48$ -50 ancestral karyotype for the Osteoglossiformes and the Mormyridae (Canitz *et al.*, 2017; Simanovsky *et al.*, 2020); these karyotypes could have resulted from centric fusions of several acrocentric chromosomes, which may also involve pericentric inversions within acrocentrics, and some fission events. Different karyomorphs for the same species were described for some genera, including *Apareiodon*, do Nascimento *et al.*, 2018; *Hypostomus*, Paula *et al.*, 2022; and *Erythrinus*, de Souza *et al.*, 2022. In some of the above cases, they were attributed to species complexes.

At present, the direction of karyotype evolution in *Hyperopisus* cannot be ascertained; either from a $2n = 40$ (24+6sm+10st/a), FN = 70 (Nigerian population), to $2n = 40$ (24+2sm+14st/a), FN = 66 (Ethiopian population) or the reverse. Deriving the karyotype of the former from the latter would involve pericentric inversions within four acrocentrics, while the fusion of two bi-armed elements can explain the composition of the former. However, the high diversity of mormyrids in Central and West African waters (Roberts, 1975; Hopkins *et al.*, 2007; Kramer *et al.*, 2013) favours the Nigerian population karyotype as the older form.

Similarly, Uyeno (1973) reported $2n = 48$ (1m+4sm+43sta), FN = 53, as the chromosome complement of *B. brachyistius*, the result of $2n = 50$ (50am), FN = 50 obtained for the same species in the present study differ in chromosome number, distribution of uni and bi-armed chromosomes and homologous pairs. The reduction in diploid chromosome number and the presence of a metacentric and an acrocentric without homologous pairs in the Uyeno's result may be attributed to incomplete chromosome spread, even though it was thought to be due to chromosome heteromorphism (Uyeno, 1973). Since the origin of Uyeno's (1973) specimen was uncertain, the possibility of sampling a cryptic or a different species cannot be ruled out. Indeed at least two previous studies on the Osteoglossiformes karyotype have exhibited differences from the ones reported by Uyeno (1973). The differences are not clearly understood but have been attributed to the presence of cryptic species, population differences or species misidentification (Rab *et al.*, 2016; Barby *et al.*, 2018). The unidentified *Brienomyrus* species sampled by Ozouf-Costaz *et al.* (2015) had a karyotype of $2n = 50$ (2m+6sm+42a); its karyotype organization is similar to the one obtained in the present study in possession of $2n = 50$ but differed in the distribution of chromosome arms.

Arnegard & Hopkins (2003) analyzed the (EOD)s of seven groups of morphologically similar *Brienomyrus* from a recently discovered mormyrids flock in Gabon. In the study, distinct species-typical EODs were discovered, suggesting the occurrence of many undescribed *Brienomyrus* species. Similarly, three *Brienomyrus* karyomorphs have been described, excluding the yet-to-be-described karyotypes of *B. longianalis* and *B. adustus*; this scenario is suggestive of more than three species in the *Brienomyrus* genus.

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FISH GEAR TECHNOLOGY

FISHING GEAR AND CRAFT TYPES USED BY ARTISANAL FISHER'S IN ESCRAVOS ESTUARY, NIGER DELTA, NIGERIA

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ABSTRACT

Fishing gear and craft types used by artisanal fisher's in Escravos Estuary, Niger Delta, Nigeria was studied between May, 2021 and April, 2022 in Niger Delta region of Nigeria. The aim is to evaluate fishing gear and craft types majorly used by artisanal fishers in the study area. Twenty communities namely: Egwa 1, Egwa 2, Gbongbene, Sonegbene, Alelegbene, Pepegbene, Kunukunu-Ama, Pilinegbene, Imegbene, Bekenegbene, Ororogbene and Gbonegbene Okerenkoko 1, Okerenkoko 2, Okerenkoko Zion, Benigbene, Alelegbene, Ekparagbene, Kurutie, Kpokpogbene were selected for the sampling framework. A total of 300 questionnaires were distributed out, 15 to each community for the artisanal fishers. A two stage random sampling technique was used in the selection of fishers. Data obtained was assembled and analyzed using descriptive statistics, frequency and percentages. The results revealed that females constituted 73.33% of the entire population and 26.67% were males. Majority (33.33%) of the fishers were within the agile age bracket of 31-40 years and 12.67% were within the non-active age (above 50 years). Ita trap (22.33%), Gillnet (18.33%) and Ngo trap (13.33%) were the majorly used fishing gear while Stow net (3.33%) was the least used fishing gear. The paddled crafts (91.00%) were the commonly used fishing crafts while 9.00% only used motorized crafts. Traditional fishing gear and crafts are still in use in the study area. Further studies are therefore recommended to ascertain a comprehensive data on the fishing gear and crafts used by artisanal fishers within and outside this water body in the Niger Delta.

Keywords: Fishing crafts, Fishing gear, Escravos Estuary, Niger Delta

Introduction

Fishing gear are the equipment used in catching fish from water bodies, and such equipment include: entangling nets, drift nets, lift nets, cast nets, clap nets, spears, traps, hooks and lines, gill nets, trawls, seine nets etc (Tagago *et al.*, 2011; Davies and Kwen, 2012; Kwen, 2019) while fishing crafts are devices used in conveying fishers from landing sites to fishing points or grounds or sites. Due to different habits and habitats of the arrays of fish species in a particular water body, different fishing gears are also being used for catching fish (Tagago *et al.*, 2011). According to Abdul (2005) and Ibrahim and Ogueji (2017), the various type of fishing gear and the way they are been used on water depend on the fishers' financial position, water depth, shoreline patterns, targeted fish species and seasons of the year. In Nigeria, fishers involved in small-scale fisheries using fishing gear and crafts that are made of both natural and synthetic (man-made) fibers (Ibrahim and Ogueji, 2017). Seasonal changes in species diversity and abundance have given ways to the invention of diverse fishing gear yearly (Bankole *et al.*, 2003). According to Du feu *et al.* (1997) different fishing gears were used by different fishers depending on the season of the year. Currently, as a result of the advances of technology in the society, it has led to the improvement of the types of fishing gear used by artisanal fishers in most water bodies (Reed *et al.*, 1967). The types of fishing gear used by fishers might be due to the peculiarity of the physical characteristics of the water body and availability of different types and size of fish species found in that location. For the fishers to effectively use fishing gear in any water body for their fishing operation successfully they need a kind of mobility to enable them get to both near and distant fishing grounds (Ibrahim and Ogueji, 2017). However, despite the important role fishing gear and crafts play in fishing operations in the Escravos Estuary around Okerenkoko and Kurutie axis there is little or no documented data on the different types of fishing equipment used by the artisanal fishers in study area. This

study is therefore intended to examine the different fishing gear and crafts used by artisanal fishers in Escravos Estuary, Niger Delta, Nigeria. The findings from this study will greatly assist fisheries experts and environmentalists in monitoring the types of fishing gear and crafts used in order to manage this water body sustainably.

Materials and Methods

Study Area

The study area is located in Escravos Estuary around Okerenkoko and Kurutie fishing Communities in Warri South-West Local Government Area of Delta State, Nigeria. Escravos Estuary is situated between latitude $5^{\circ}30'0''\text{N}$ and $5^{\circ}50'0''\text{N}$ and Longitude $5^{\circ}10'0''\text{E}$ and $5^{\circ}40'0''\text{E}$ (Figure 1). The area is characterized by active beaches on the seaward sides. The surrounding Eseravos Estuary is characterized by a tropical climate. With well demarcated rainy and dry seasons. The dry season stretches from November to April while the rainy season is usually from May to October (Opule, 2000). The vegetation is made of *Eichhornia crassipes*, *Fern*, *Pistia*, *Pennisetum Purpureum*, *Cenchrus*, *Ciliaris*, *Nympkarasp*, *Trapasp*, *Lemnasp*, *Ceratrpphyllum sp.* The human activities that are carried out in the study area include: offloading and selling of goods and petroleum products, boat transportation, dumping of organic and inorganic wastes, log movement, washing of clothes and boats, bathing and swimming.

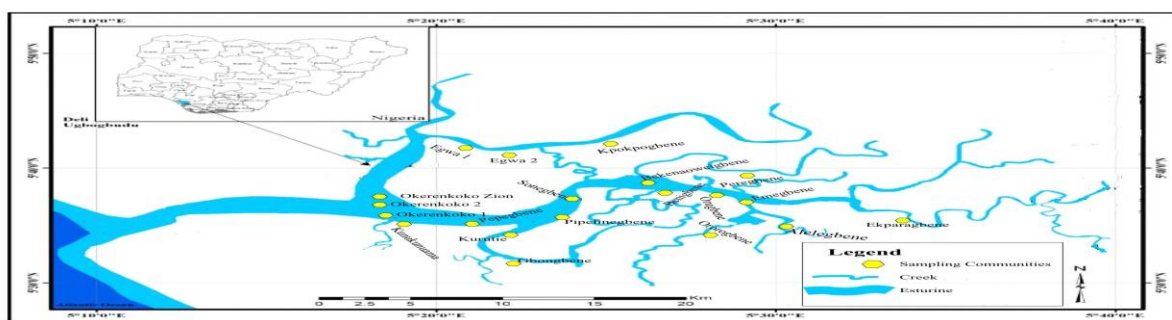


Figure 1. Map of the Study Area, Showing Sampling Communities

Selection of Locations

The sampling locations were selected based on preliminary investigation from artisanal fishers operating along the Escravos Estuary around Okerenkoko and Kurutie. The locations selected were greatly influenced by the fishing activities in those Communities. All communities share very close ties, often participating in common fishing trips and other economic activities and are major fishing landing sites along the study area.

Sampling Technique

Twenty communities namely: Egwa 1, Egwa 2, Gbongbene, Sonegbene, Alelegbene, Peppegbene, Kunukunu-Ama, Pilinegbene, Imegbene, Bekenegbene, Ororogbene and Gbonegbene Okerenkoko 1, Okerenkoko 2, Okerenkoko Zion, Benigbene, Alelegbene, Ekparagbene, Kurutie, Kpokpogbene were selected for the sampling framework. A total of 300 questionnaires were distributed out, 15 to each community for the artisanal fishers. A two stage random sampling technique was adopted in the selection of fishers. Some of the information the questionnaires covered include biodata of the artisanal fishers, fishing gear and craft types used and income generated daily from their catch. The study was carried out for a period of one year between May, 2021 and April, 2022.

Statistical Analysis of Data

Data obtained was assembled and analyzed using descriptive statistics, frequencies and percentages.

Results and Discussion

The biodata of the respondents is shown in Table 1. The results revealed that females constituted 73.33% of the entire population of the respondents in Escravos River Estuary in Delta State and 26.67% were males. The high proportion of female members dominating the artisanal fishing activities could be as a result of the

fact that fishing activities in the study area are devoid of gender limitations and women were more predisposed towards fishing and fish products than their male counterparts (Yamhere, 2011; Ibitoye, 2012). Another cause is that, men in the area are no longer interested in fishing due to the introduction of mini-refineries around the area that generates more funds to them than fishing. Kwen *et al.* (2013) in their study on the survey of fishing gear and status of artisanal fishers in Igbedi Creek, Nigeria Delta, Nigeria also reported that females dominated in the fishing activities in the study area. A contrary view was reported by Agbontale (2009) that marketing is seen as a preferred work for women and not fishing operations. The age of the respondents indicated that majority (33.33%) of them were within the age bracket of 31-40 years and the others were either 21-30 years (30.00%), 41-50 years (23.33%) and above 50 years (12.67%). From this results, it is evident that most of the respondents were within the economically active age. This is an indication that, the artisanal fishers in this study area were relatively young and is predominantly being carried out by young people. Therefore, training, extension and spread of knowledge would be quite effective for people of such age bracket. This is in agreement with the reports of Mebine and Adeyemo (2012), Davies and Kwen (2013) and Kwen and Nwabeze (2014) who had reported that fishing activities including processing and marketing are majorly carried out by people within the ages of 30-40 years. This could be due to the fact that; youths normally go about doing their personal business without any challenges of old age. Most of the respondents (60.00%) were married with household size of 1-5 (66.67%). The high percentage of married people involvement in fish marketing is in line with the reports of Onyia and Adebayo (2006), Misau *et al.* (2012), Kwen *et al.* (2013) and Kwen and Nwabeze (2014) who reported that the social aspect of fisheries is been dominated by married people, and some of their activities include: processing, preservation, transportation, marketing etc. This suggest that they are the people who have more pressing responsibilities to cater for than those who are single. The educational level of the respondents revealed that, majority of them (53.33%) had primary education while 23.33% and 6.67% had secondary and tertiary education. Only 16.67% of the respondents were without formal education. This low level of education may discourage active participation and acceptance of new innovations that will enhance artisanal fishing operations and other agricultural activities. In terms of the years of experience by the artisanal fishers, majority (66.67%) of them had over 15 years fishing experience, 30.00% had 11-15 years' experience while 3.33% only had 5-10 years' experience.

Table 1: Biodata of artisanal fisher's in Escravos Estuary

Variables	Frequency	Percentage (%)
Sex		
Male	80	26.67
Female	220	73.33
Total	300	100.00
Age		
21-30	93	31.00
31-40	100	33.33
41-50	70	23.33
Above 50	38	12.67
Total	300	100.00
Marital Status		
Single	40	13.33
Married	180	60.00
Widow	80	26.67
Total	300	100.00
Household Size		
1-5	200	66.67
5-10	90	30.00
Above 10	10	3.33
Total	300	100.00
Educational Level		
No Formal Education	50	16.67

Primary	160	53.33
Secondary	70	23.33
Tertiary	20	6.67
Total	300	100.00
Years (Yrs.) of Experience		
5-10 Yrs.	10	3.33
11-15 Yrs.	90	30.00
Above 15 Yrs.	200	66.67
Total	300	100.00

Source: Field Survey, 2021.

The types of fishing gear been used in the study area is represented in Table 2. Most (22.33%) of the artisanal fishers in the study area used more of the Ita trap, followed by Gillnet (18.33%), Ngo trap (13.33%) and the Stow net (3.33%) was the least used fishing gear. Pictographs of some of the fishing gear used by artisanal fishers in the study area is shown in Plates 1-9.

Table 2: Types of fishing gear used in Escravos Estuary

Gear Type	Frequency	Percentage (%)
Ita Trap	67	22.33
Gill Net	55	18.33
Ngo Trap	40	13.33
Beach Seine Net	29	9.67
Lift Net	25	8.33
Cast Net	23	7.67
Long Line	20	6.67
Hook and Line	16	5.33
Scoop Net	15	5.00
Stow Net	10	3.33
Total	300	100.00

Source: Field Survey, 2021.



Plate 1: Cast-net



Plate 2: Gill-net



Plate 3: Longline

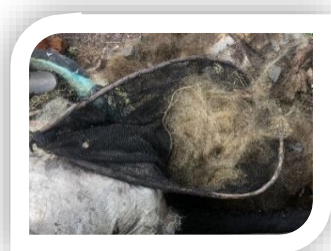


Plate 4: Scoop-net



Plate 5: Beach Seine Net



Plate 6: Ita Trap



**Plate 7: Stow net
Traps**



Plate 8: Lift net



Plate 9: Ngo (Funnel basket)

Figure 2 portrays the types of fishing crafts used by artisanal fishers in Escravos Estuary. Ninety-one (91.00%) percent of the respondents used more of the paddled crafts while just few (9.00%) of them used the motorized crafts. This is a confirmation that artisanal fishers in the study area used more of the paddled crafts than the motorized crafts. This could be as a result of the fact that the paddled crafts are less expensive when compared to the motorized crafts. Photographs of fishing crafts used by the artisanal fishers is depicted in Plates 7-8.

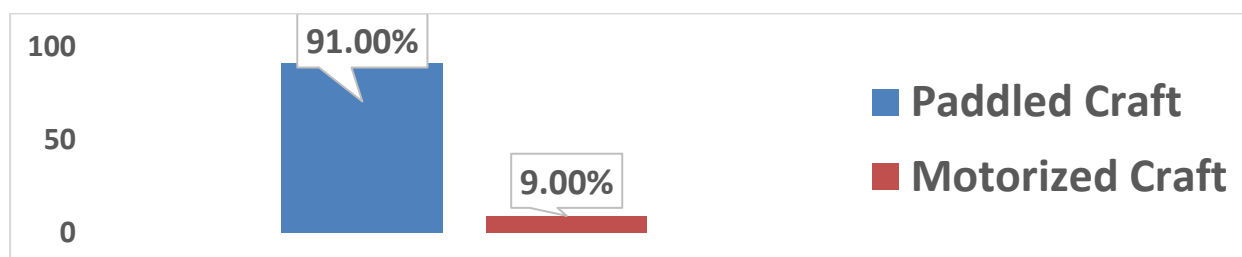


Figure 2: Types of fishing crafts used by artisanal fishers in Escravos Estuary.



Plate 7: Motorized Craft

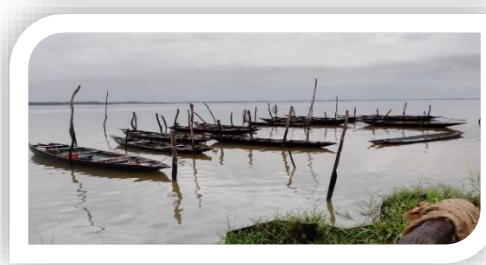


Plate 8: Paddled Crafts

CONCLUSION

The females were more involved in artisanal fisheries in the study area than their male counterparts. The most economically active age engaged in artisanal fisheries was within the age bracket of 26-50 years. The study revealed that different types of fishing gear and crafts were used by artisanal fishers in the Escravos Estuary. Traditional fishing gear and crafts are still in use. The majorly used fishing gear in the study area were Ita trap, Gillnets and hook and Ngo trap while the majorly used fishing crafts were paddled crafts. High cost of motorized crafts contributed to low or non-usage in the study area. Further studies are therefore recommended to ascertain a comprehensive data on the fishing gear and craft types used by artisanal fishers within and outside this water body in the Niger Delta.

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EFFECT OF FISHING GEARS USED BY FISHERFOLKS ON THE YIELD OF FISH IN RIVER BENUE

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ABSTRACT

This study was conducted to ascertain the effects of fishing gear used by fisherfolks on the yield of fish in River Benue, Nigeria. The study was conducted in three fishing villages that are also landing sites. They are within Adamawa State axis with the Benue River passing through them. The selected villages are Boranji (Site 1), Damare (Site 2) and Hayin gada (Site 3). The study was conducted bi-monthly for three months from the month of July to September 2021. This study used both primary and secondary method of data collection. A total of One Hundred and Forty (140) respondents were sampled with structured interview and questionnaire. The study showed that the fishing gears employed and operated in the study area are used to capture different fish species. The most prominent of the gears is the Gill-net and Malian trap. The study also revealed that Sixteen (16) fish species from seven (7) families were caught by the six artisanal fishing gears in all the sites. The study revealed obvious neglect of the artisanal fisherfolks in terms of infrastructural facilities despite their immense contribution to the domestic fish output.

Keywords: Fisheries, Fishing gear, River Benue, Artisanal fisheries, Catch

Introduction

Artisanal fishery sector constitutes the most important sector which accounts for major fish supply in the developing world. However, attempts to harness the full potentials in this sector have failed due to the enormity of poverty which constantly put the fisher folk on the brink of economic stagnation and incapacitation. Fisheries statistics is the primary means to measure the social, economic, biological, and environmental performance of the fishery (FAO, 2002). Fishes are renewable resources which should be exploited rationally on sustainable basis. To derive maximum benefits from them, it is necessary to evolve rational effective management that will make the resources available now, and in the future, at the time we need them in a very good condition at affordable prices and should improve the socio- economic well-being of the resource users and should be environmentally friendly.

The amount of catch in River Benue has depleted drastically over the years due to the use of some inappropriate gears. This is a big threat to the capacity of these fishery ecosystems to continue providing for the livelihood of many communities which are highly dependent on their harvest. The practice of illegal, unsustainable, or irresponsible fishing practice particularly the use of gears with undersized mesh sizes. This low catch has also affected the family of the fisher-folks. Fishery management requires a good knowledge of the fishing gear. There is great divergence in the efficiency of different forms of fishing gear, in their adaptability to certain conditions, and their desirability for specific job. Traditional fishing arts have been developed over the years to adapt to local body conditions; the species of fish desired and targeted size. The most successful fishing methods of an area or a region are those that have stood the test of time. The aim of this study is to ascertain the effects of fishing gear used by fisherfolks on the yield of fish in River Benue.

Material and Methods

Study Area

The Benue River originates in the Adamawa mountains of the Central Cameroon and flows westward for about 1,400 km until it meets the Niger River about 450 km above the delta, near the city of Lokoja, Kogi State, Nigeria (Ashley, 2010). During the rainy season, the River Benue overflows its banks and inundates the grassy riparian zones. However, during the dry season the water level in the river recedes considerably leaving a silted river bed with clear shallow water (Solomon, *et al.*, 2009).

Sampling Units

The study was conducted in three fishing villages that are also landing sites. They are within Adamawa State axis with the river Benue passing through them. The selected villages are Boranji (Site 1), Damare (Site 2) and Hayingada (Site 3). The study was conducted bi-monthly for three months from the month of July to September 2021.

Method of Data Collection

This study used both primary and secondary method of data collection. The primary data included the use of structured interview and questionnaire while the secondary data include the use of journals, textbooks, bulletins, magazines, etc.

Questionnaire administration and Focus Group Discussion

A total of One Hundred and Forty (140) respondents were sampled with structured interview and questionnaire to obtain data on the number of fishermen and the number of gears along the landing sites for the three months period. Thirty fisherfolks were also purposively selected for the focus group discussion (FGD) in each of the communities.

Catch effort calculation

The catch per unit effort (CPUE) for the gears were taken based on the weight of fish caught during a fishing day (kg day^{-1} fishing unit $^{-1}$) for the different species combined. The catch efficiency of each gear employed in each fishing site was analyzed by comparing different gear on the basis of CPUE, i.e., the amount of fish caught for a certain period, for example amount of fish caught per day. Fluctuations in the fish catch were also compared. The CPUE value was extrapolated to the mean catch gear $^{-1}$ day $^{-1}$ person $^{-1}$, mean catch crew $^{-1}$ day $^{-1}$ (MCCD) and mean catch boat $^{-1}$ day $^{-1}$.

Statistical Analysis

All data collected were analyzed using simple descriptive statistics; frequency distribution, total and percentages, which was used to determine differences between the sample attributes. Means of data that was generated was represented using tabular and graphical representations. The coefficient of variation (CV) analysis assessed the variability in the CPUE by gear types.

Results and Discussion

Demographic Characteristics and Fishing Livelihood of Fisherfolks in the Study Area

The result of the demographic characteristics and fishing livelihood of fisherfolks in the study areas is presented in table 1. According to the result, majority of the respondents in the study area were males (82.15%) while females were only 17.85%. Fisherfolks with age range between 20-30 years old recorded the highest value (25.71%) while fisherfolks with age range between 50 and above obtained the least value (20.00%). Majority of the respondents (45.00%) were single while divorcees were the least (7.1%) of the fisherfolks analyzed. Household size range of 4 – 6 recorded the highest value (54.28%) while that of 7 and above recorded the least (16.44%). With respect to language spoken in the study area, most of the fisherfolks speak Hausa (54.28%) but only 7.85% speak English language which recorded the least.

Most of the fisherfolks in the study area practice small-scale method of fish farming with 67.85% representation while only 8.57% practice the large-scale farming. Just about 23.58% of the fisherfolks practice both large-scale and small-scale farming.

Table 1: Demographic characteristics and fishing livelihood of the respondents

Variable	Category	Frequency	Percentage
Gender	Male	115	82.15
	Female	25	17.85
Age	<20	5	3.57
	20 – 30	36	25.71
	31 – 40	30	21.45
	41 – 50	41	29.28
	51 and above	28	20.00
Marital status	Single	63	45.00
	Married	50	35.00

	Divorce	10	7.1
	Widow	17	12.9
Household size	1 – 3	41	29.28
	4 – 6	76	54.28
	7 and above	23	16.44
Language spoken	English	11	7.85
	Hausa	83	59.30
	Others	46	32.85
Method of fishing	Small scale	95	67.85
	Large scale	12	8.57
	Both	33	23.58
How long have you been fishing?	1 year	36	25.71
	2 – 5 years	57	40.71
	6 years and above	47	33.57
How many fishing trips embarked?	Once	83	59.28
	Twice	42	30.0
	Thrice and above	15	10.71
Duration of fishing trips	1 – 2 hours	18	12.85
	3 – 4 hours	53	37.85
	5 hours and above	69	49.28

Types of fishing gears used in River Benue

The different types of fishing gears used by fishermen in the study area is presented in Table 2. A total of (six) 6 different gear types were identified and the commonest ones used by fisher-folks at the different study sites were lift net (Akauji), longline (Rincha), fishing spear (Mashi), Malian trap (Gura/Malia), gill net (Taru) and cast net (Birgi). Of these 6 artisanal fishing gear types, four (4) are commonly used in site A (Boranyi) except for lift net and cast net. In site B (Damare), only cast net and gill net were not commonly used of the six gears identified, while five (5) gears were used in site C (Hayin Gada) where only fishing spear was not commonly used. Fig. 1 shows the occurrence proportion of the different gears sampled in the different sites during the study period.

Table 2: Fishing Gears Identified in the Study Sites

Gear	Local Name	Site A (Boranyi)	Site B (Damare)	Site C (Hayin Gada)
Lift nets	Akauji	-	+	+
Longline	Rincha	+	+	+
Fishing spears	Mashi	+	+	-
Malian Trap	Gura/Malia	+	-	+
Gill net	Taru	+	-	+
Cast net	Birgi	+	+	+

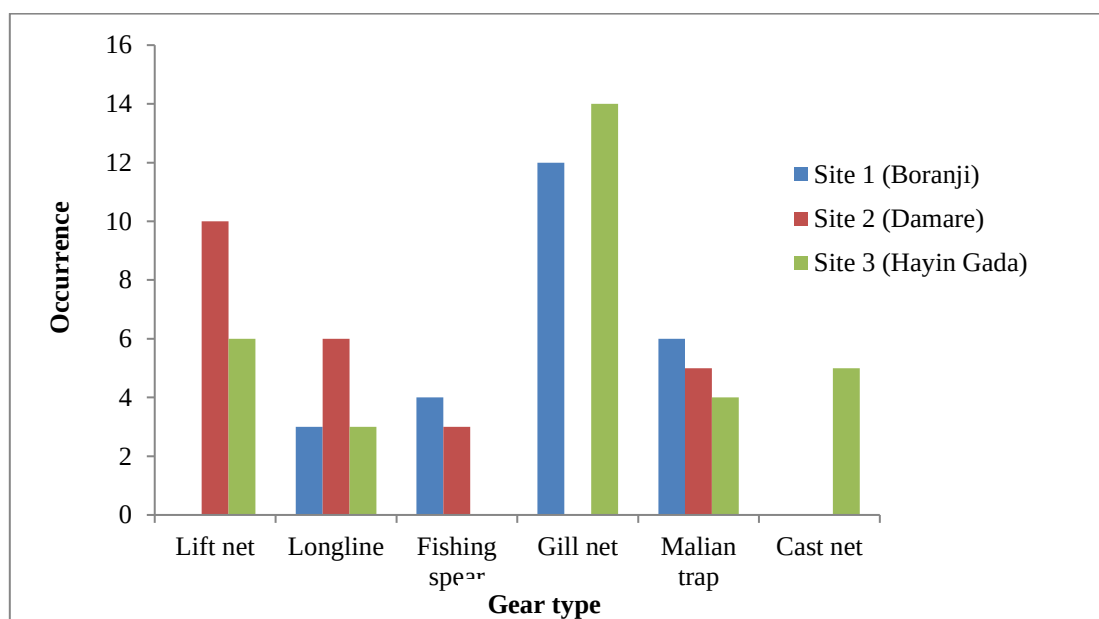


Fig 1: Fishing gears distribution across the study sites

Determination of different catch made using the gears

The different catch made using the different six (6) gears identified in the study sites is presented in Table 3. A total of seven (7) families of fish and sixteen (16) species of fishes were identified. Site 2 (Damare) landing site had the highest number of fish catch followed by site 1 (Boranji) while site 3 (Hayin Gada) had the least number of catches.

Table 3: Common catches of the different fishing gears used in the study areas

Family/species	Gill net	Cast net	Lift net	Long line	Malian trap	Spear	Abundance
SITE 1							
Cichlidae							
<i>Oreochromis niloticus</i>	+	+	+	+	+	+	300
<i>Sarotherodon galileus</i>	+	+	+	+	+	+	200
Claridae							
<i>Clarias gariepinus</i>	+	+	+	+	+	+	320
<i>Heterobranchus bidorsalis</i>	+	-	+	-	+	-	10
Claroteidae							
<i>Auchenoglanis occidentals</i>	+	+	+	+	-	-	22
Alestidae							
<i>Alestes spp</i>	+	+	+	+	-	-	540
SITE 2							
Cichlidae							
<i>Oreochromis niloticus</i>	+	+	+	+	+	-	415
<i>Coptodon zilli</i>	+	+	+	+	+	-	100
Claridae							
<i>Clarias gariepinus</i>	+	+	+	+	+	+	400
<i>Heterobranchus bidorsalis</i>	+	-	-	-	+	+	2
Citharinidae							
<i>Citharinus citharus</i>	+	+	-	+	+	-	22
Mormyridae							
<i>Mormyrops anguivoides</i>	+	+	+	-	+	-	10
<i>Mormyrus rume</i>	+	-	-	-	+	-	5
Mochokidae							
<i>Synodontis schall</i>	+	+	+	+	+	-	40
<i>Synodontis budgetti</i>	+	+	+	-	+	-	12

Alestidae							
<i>Alestes spp</i>	+	+	+	-	-	-	652
<i>Hydrocynus forskalii</i>	+	+	+	-	-	-	436
SITE 3							
Cichlidae							
<i>Oreochromis niloticus</i>	+	+	+	+	+	+	295
<i>Coptodon zilli</i>	+	+	+	+	+	+	70
<i>Tilapia zilli</i>	+	+	+	+	+	+	100
Claridae							
<i>Clarias gariepinus</i>	+	+	+	+	+	+	235
<i>Heterobranchius bidorsalis</i>	-	+	+	-	-	-	15
Citharinidae							
<i>Citharinus citharus</i>	+	+	+	+	-	-	24
Mormyridae							
<i>Mormyrus rume</i>	+	+	+	-	+	-	17
Mochokidae							
<i>Synodontis schall</i>	+	-	+	+	-	-	62
<i>Synodontis budgetti</i>	+	+	+	-	-	-	15

Fishing yield in the Study Area

The effect of the different fishing gears on the yield of the catch in the different study sites is presented in Table 4. The average yield (kg) obtained in the sampled sites showed that the Cichlidae family had the highest value (785.43kg) while Mochokidae family had the least value of (180.83kg). However, there was a variation between the %number and %weight of the different catch. The Differential weight (gm) of the fish catch was highest in Mochokidae family and least in Alestidae.

Table 4: Variations in fishery yields in all sampled areas of River Benue

Family	Yield (kg)	% Number	% Weight	Differential weight (gm)
Cichlidae	785.43	30.84	20.87	729.5
Claridae	693.5	21.14	16.9	1318.7
Citharinidae	305.8	13.7	11.2	754.3
Mormyridae	415.3	12.4	15.94	582.6
Mochokidae	279.85	4.84	5.38	793.4
Alestidae	458.98	12.43	11.58	250.0
Claroteidae	298.10	2.8	14.37	237.3
Bagridae	180.83	1.85	3.76	439.7
Total	3,417.79	100	100	5,105
Mean	427.22	12.5	12.5	638.19
S. Deviation	317.93	23.9	9.7	541.9

According to results obtained of the demographic characteristics of the respondents in table 1, majority of the respondents in the study sites were males (82.15%), which reveal the predominance of the male gender in fishing business especially in the study area. This could be attributed to the associated risk, masculine, and tough nature of artisanal fishing. This is in line with the findings of Dauda *et al.* (2018). Most of the respondents (29.28%) were within their active age (41 – 50 years), which could enhance productivity since age is an important factor that affects fishing productivity (Nwabeze and Erie, 2013). At this age range, fishers have been reported to be more active and fishing becomes attractive business as reported by Nwabeze and Erie (2013).

Majority of the respondents (45.00%) were single and 35.00% were married with 4 – 6 persons per household, which agrees with the report of Dauda *et al.* (2015). Majority of the respondents (59.30%) speak Hausa, this may be due to the fact that the sites are predominantly Hausa communities. Also, majority of the respondents' method of fishing were small-scale with 67.85%.

As indicated in Table 1, fish artisans in the study sites used different gears ranging from cast nets, gill net, lift net, fishing spear, Malian trap, and long line for fishing. Gear usage is a function of fish species diversity, abundance, and the nature of water body. Due to different habits and habitats of the arrays of fish species in a particular water body, different gears are also being used for capturing fish (Tagago *et al.*, 2011). This is in line with the findings of Ibrahim *et al.* (2017) who studied that artisanal fishery activities in the River Benue of Nigeria are majorly noted with diverse species and multiple gear activities.

Cast net and long line was widely used among the fish artisans who attest to its availability and within their reach; it is effective for catching small bait or forage fish, and has been in use, with various modifications, for thousands of years. Alegbeleye *et al.* (2003) asserted that cast nets are used all year round, night and day and the catch per unit effort could be great, though the operation is somehow very exerting. Reports however showed that gillnet is the most important gear used by fishermen in the Northern part followed by long lines and cast nets (Emmanuel, 2019). Generally, Malian traps are not destructive for the water body except fishing with setting up of barrier on the path/migratory route of fish movement which does not allow selectivity and could cover a large area. This result agrees with the findings of Ibrahim *et al.* (2009) reported the use of gillnet, cast net, hook and line, Malian/Gura, clap net and Giwa net in Northern Nigeria. The dominance of these gears widely used in artisanal fisheries could be adduced to their result in efficiency, relatively inexpensive and capable of catching higher amount of economically valuable fish.

Sixteen (16) fish species from seven (7) families were caught by the six artisanal fishing gears in all the sites including Boranji, Damare, and Hayin Gada (Table 3). Majority of the species caught in the study areas are of high commercial value while only a few were of low value. The target fishes caught by the gears are primarily Bagrids, Schilbeids, Clariids, Mochokids, Characids, Citharinids, Heterotis and host of others. This finding is similar to that of Dauda *et al.* (2013). Also, the findings shows that Cichlidae family had the highest weight (kg), and number of fish catch while the least were Mochokidae family. This agrees with the findings of Kwajo *et al.* (2015).

CONCLUSION

The fishing gears (Gill net, cast net, lift nets, longline, Malian trap, spears) employed and operated in the study area are used to capture different fish species. The most prominent of the gears is the Gill-net and Malian trap. Cast net is used and selects suitable water body and thus fishermen at the study area enjoy its usage during the high-water level with low current. Most of the fishing gears have significant variations and modifications aimed solely to capture targeted species. Sixteen (16) fish species from seven (7) families were caught by the six artisanal fishing gears in all the sites. The study revealed obvious neglect of the artisanal fisherfolks in terms of infrastructural facilities despite their immense contribution to the domestic fish output.

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EFFECT OF COLOURED NETS AND MESH SIZES ON THE CATCH EFFICIENCY OF MULTIFILAMENT GILLNET IN KAINJI LAKE

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ABSTRACT

Three sets of surface multifilament gillnets with 64mm, 76mm and 89mm mesh sizes of 15m by 4 different colours (white, green, yellow and black) making a total length of 60m each and 3m depth, hang at 50% (E-0.5) were design and constructed. Experimental fishing trials for the gillnets were carried out at Musawa fishing ground, Southern Basin of Kainji Lake for six months. A total number of 264 Fish were caught in all the coloured nets in the six months of the experimental work, with White net having the highest number of 87 (32.95%). The percentage occurrence of fish species caught in all the coloured nets pooled together showed that *Lates niloticus*, *Oreochromis niloticus*, *Synodontis nigrita*, *Bagrus bayad* and *Tilapia zilli* were the most abundant species caught in that order and they constituted about 68% of the total number of fish caught. The total weight of fish caught in all the coloured nets was 64.27kg; Yellow net had the highest weight of 21.09kg (32.81%). The differences in variation of the total fish caught by the different coloured gillnet were found insignificant according to result of the three way analysis of variance. However, it was observed that black coloured net was significantly lower than other coloured nets. From the result it could be suggested that the use of different coloured nets could allow selection of fish species and less unwanted bycatch.

Keywords: Coloured net, Meshsize, catch efficiency, Gillnet, Kainji Lake

INTRODUCTION

Gillnet is one of the oldest types of fishing gear and is widely used to harvest diverse marine and freshwater species. Gillnets are classified as a passive gear, consisting of a large wall of netting which can be set at or below the surface of the water body. Its construction can be single, double or triple (trammel net) netting. Depending on the operation, gillnet can be drifting, fixed or encircling. Fish caught in gillnets are usually gilled, but can be wedged, snagged or entangled. The net is kept open vertically by the differences in buoyancy between the head rope and the foot rope, the head-rope is given positive buoyancy by using various floating devices while the foot rope is given negative buoyancy by using sinkers.

It has been reported that the net mesh size, body shape, fish size, hanging ratio, net colour, the thickness, the flexibility of the netting twine, the visibility of the twine and fish behavior affect the selectivity of gill nets. Kainji Lake is known to experience two types of seasons, the Raining season (white flood) and the Dry Season (black flood), during these seasons the Lake changes colour drastically. The local fishermen do not consider the colour net to be used at a particular season but they use white net at both seasons and this may not give the best catch. The fishermen do not also consider the mesh size of net used, mesh size far less than the recommended size (76mm) is used and this has negative effects on the fish population of the Lake. Hence, the objective of this study is to determine the effects of coloured net and meshsize on the catch efficiency of multifilament gillnet in Kainji Lake.

MATERIALS AND METHODS

Construction Site and Study Area

The experimental gillnets were tried at Musawa fishing ground, Southern Basin of Kainji Lake, which is located between (Latitude 9°51'45.13"N) and (Longitude 4°34' 11.6" E) for six months.

Based on FAO (2015) methods, three sets of surface multifilament gillnets with 64mm, 76mm and 89mm mesh sizes of 15m by 4 different colours (white, green, yellow and black) making a total length of 60m each and 3m depth, hang at 50% (E-0.5) were design and constructed. The required meshes in dimension of the gear were calculated based on the formula of Eyo and Isangedighi (2016): the number of meshes needed for the length and depth were worked out taking into consideration the mesh size and hanging percentage.

Experimental Design (3x 4 Factorial Designs)

The nets were ganged together randomly using randomized numbering techniques to form a fleet of 12 gangs of net, based on Adimula (2003) method. It was done this way so as to eliminate the possibility of a fish being led to a particular mesh size and colour.

Net Recovery

Three selected fishing location were sited (the Lower stratum, the mid stratum and the upper stratum), 90 sampling fishing days each for the two seasons (Black Flood and White Flood) were done making sure that every 14 days the nets location were changed within the stratum. The nets were set in the evening (between 7pm –8 pm) and hauled the following morning (between 6am – 7am) to determine the catch for night time and set in the morning (between 7.30am-8am) and hauled in the evening (between 6pm-7pm) to determine the catch for the day time . The catches were carefully removed as the net was hauled into the boat. The catches were then separated according to the mesh sizes and coloured nets that caught them and were sorted into their respective species using fish identification keys prepared by Olaosebikan and Raji (2013) as taxonomic guide.

Data Analysis

At the end of the experiment, the data collected were analyzed for the following information:

Total number, Total length and body weight of the fish caught by each mesh size and net colour

The size of fish caught, Species diversity index and Mode of capture of fish by each mesh size

The Relative species diversity index (RSDI) was computed based on the formula provided by Ahmed, (2005):

$$RSDI = \frac{\text{Number of species caught by each coloured gillnet}}{\text{Total number of species caught by all the coloured gillnet}}$$

The data obtained from the work was subjected to statistical analysis of variance (ANOVA) using the biomass of fish caught by the different mesh sizes and the coloured gillnets.

RESULTS AND DISCUSSION

Catch Composition

A total number of 264 Fish were caught in all the coloured nets in the six months of the experimental work, with White net having the highest number of 87 (32.95%) fish followed by Yellow net with 81 (30.68%) fish, the least number of fish caught was recorded by black net with 39 (14.77%) fish. The percentage occurrence of fish species caught in all the coloured nets pooled together showed that *Lates niloticus*, *Oreochromis niloticus*, *Synodontis nigrita*, and *Bagrus bayad* were the most abundant species caught in that order and they constituted about 68% of the total number of fish caught (Table 1).

The total weight of fish caught in all the coloured nets was 64.27kg, Yellow net had the highest weight of 21.09kg (32.81%) fish caught, followed by White net with 20.45kg (31.82%) and Black net had the least weight of 8.91kg (13.86%) fish (Table 1).

Seasonal variations in Fish caught with the coloured gillnets

The total number of fish caught in the dry season was 130; White net had the highest number of 47 fish. The total weight of fish caught in the dry season by the coloured nets was 32.56kg, White net had the highest weight of 11.22kg fish caught and Black net had the least weight of 4.68kg fish. The total number of fish caught in the raining season was 134, Yellow net had the highest number of 48 fish. The total weight of fish caught in the raining season by the coloured nets was 31.71kg, Yellow net had the highest weight of 11.87kg fish caught followed by White net with 9.23kg and Black net had the least weight of 4.23kg fish. From the total number of fish recorded by the mesh sizes, 64mm mesh size had the highest number of 147 fish, followed by 76mm mesh size with 101 fish and the least number of 16 fish was recorded by 89mm mesh size. However, 76mm mesh size recorded the highest weight of 30.27kg fish followed by 64mm mesh size with 29.10kg and the least weight of 4.90kg was recorded by 89mm mesh size.

DISCUSSION

The species composition of fish caught shows the effectiveness of the gill nets in catching different fish species that are known to exhibit different behavioural characteristics and feeding ecology in the lake (Abiodun *et al*, 2011). However, the highest species diversity index recorded in the dry season was by white gillnet while Yellow net recorded the highest species diversity index in the Wet season (white flood) which might indicate the relative abundance of fish species in the Lake.

The species of fish caught by the different meshsizes (64mm 76mm and 89mm) were similar to those reported by Adimula for gillnet fishery in the same stratum of the Lake (Adimula, 2003). However, the dominant species (*Lates niloticus*, *Oreochromis niloticus*, *Synodontis nigrita*, and *Bagrus bayad*) vary from the ones recorded by Adimula (*Citharinus citharus*, *Oreochromis niloticus*, *Synodontis membranaceus* and *Sarotherodon galilaeus*) this might be due to the different colour of nets used in this experiment (Emmanuel and Onyema, 2007).

It was observed that the major fish species caught have preference to the different coloured nets, Yellow net caught more of *Lates niloticus*, *Bagrus bayad* and *Synodontis nigrita*, White net caught more of *Oreochromis niloticus* and *Distichodus rostratus*, Green net attracted *Polypterus senegalus* and Black net attracted *Tetraodon fahaka* and *Polypterus senegalus*, this is in line with the work of Oliver *et al*, (2012) who pointed out that the catchability of a coloured net varies from species to species and within species between a single fish and a group of fishes. Emmanuel and Onyema, (2007) reported that Fish can distinguish colours, and also different coloured nets may show significant differences in catches.

The differences in variation of the total fish caught by the different coloured gillnet were found insignificant according to the result of the three way analysis variance. However, it was observed that black coloured net was significantly lower than other coloured nets.

The Gillnets caught more number of fish during the night than in the day at a percentage of 94.70% to 5.30%. More fishes were caught at night than during the day, this could be due to the human activities during the day such as water transportation, washing and operation of active gear (cast net and beach seine nets) during the day time as a result most of the fish species were scared away, which is in consonance with the report of Eyo and Isangedighi (2016) but disagreed with that of Emmanuel and Onyema (2007), who noted that more fish were caught during the day than at night due to the fact that most of their day fishing operations was done at low tide, an indication that the time of the day does not matter but the tidal level and environmental condition of the fishing environment.

From the result it was observed that 64mm mesh size caught more number of fish than the other mesh sizes, however, the highest weight was recorded by 76mm mesh size, it is an indication that larger fish were caught by the 76mm mesh size. This agreed with the work of Cat and Yuksel, (2014) who opine that large meshsize nets have a greater efficiency for large fish.

CONCLUSION

The catch efficiency of the Multifilament coloured gillnet revealed that yellow and white coloured nets were found to be more effective for *Lates niloticus*, *Bagrus bayad*, and *Synodontis nigrita*; *Oreochromis niloticus* and *Distichodus rostratus* while green net was the only net that capture *Polypterus senegalus* while black coloured net was the only net that caught *Tetraodon fahaka*. From the result it could be suggested that the use of different coloured nets could allow selection of fish species and less unwanted by-catch.

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I give my profound gratitude to the Almighty God for Preserving my Life throughout the duration of the work, my sincere appreciation also go to those who contributed to the success of this work; they include Prof. R.J. Kolo and Prof. R.O. Ojutiku. May God continue to bless you all.

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A: Construction of Gillnet



B: Setting of Gillnet



C: Hauling of Gillnet



D: *Lates niloticus* caught by Gillnet

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Table 1: Summary of Number and Weight of Fish caught by the gillnet

Species	White		Green		Yellow		Black		Total		Percentage
	No	Wt(g)	No	Wt(g)	No	Wt(g)	No	Wt(g)	No	Wt(g)	
<i>Bagrus bayad</i>	10	2650	6	1600	14	3230	5	1700	35	9180	13.26
<i>Bagrus docmak</i>	1	500	0	0	1	300	0	0	2	800	0.76
<i>Citharinus citharus</i>	3	1250	0	0	1	500	1	200	5	1950	1.9
<i>Chrysichthys nigrodigitatus</i>	1	300	0	0	0	0	0	0	1	300	0.38
<i>Auchenoglanis biscutatus</i>	1	130	1	400	0	0	1	250	3	780	1.14
<i>Oreochromis niloticus</i>	17	3810	8	1850	7	1350	6	1250	38	8260	14.39
<i>Oreochromis aureus</i>	5	1130	4	900	4	1000	4	700	17	3730	6.44
<i>Tilapia zilli</i>	4	600	5	900	6	700	5	910	20	3110	7.58
<i>Hemichromis fasciatus</i>	0	0	0	0	1	100	0	0	1	100	0.38
<i>Labeo coubie</i>	4	880	5	1000	1	250	3	730	13	2860	4.92
<i>Lates niloticus</i>	16	3810	11	3580	18	6260	9	1970	54	15620	20.46
<i>Distichodus rostratus</i>	9	1850	2	350	10	3200	1	200	22	5600	8.33
<i>Synodontis membranacea</i>	1	300	0	0	0	0	0	0	1	300	0.38
<i>Synodontis nigrita</i>	9	2050	12	2500	13	3469	2	500	36	8519	13.64
<i>Hyperopisus bebe</i>	0	0	0	0	1	50	0	0	1	50	0.38
<i>Mormyrus rume</i>	4	940	2	490	4	680	0	0	10	2110	3.79
<i>Polypterus senegalus</i>	0	0	1	250	0	0	1	250	2	500	0.76
<i>Tetraodon fahaka</i>	0	0	0	0	0	0	1	250	1	250	0.38
<i>Hydrocynus forskalii</i>	2	250	0	0	0	0	0	0	2	250	0.76
Total	87	20450	57	13820	81	21089	39	8910	264	64269	100
Mean Weight (g)		235.06		242.46		260.36		228.46		243.44	

EFFECTS OF DIFFERENT HANGING RATIOS ON THE CATCH EFFICIENCY OF MULTIFILAMENT GILLNET IN KAINJI LAKE

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ABSTRACT

Three sets of gillnets with 0.3, 0.5 and 0.7 hanging ratios of 15m long and 76mm Meshsize were constructed at the gear workshop unit of Federal College of Freshwater Fisheries Technology, New Bussa. Operation of the gillnets were carried out at Monia/Taada fishing ground, Southern Basin of Kainji Lake for 30 days, fish caught were sorted into their various species. A total number of nine fish species belonging to Four Families were caught by the experimental gillnets, the species composition of the fish caught shown the effect of size selectivity and efficiency of varying hanging ratio (0.3, 0.5 and 0.7). The number of fish caught, the weight and percentage of fish caught by different hanging ratios indicated that 0.3 hanging ratio caught 4 fish weighing 1280g, 0.5 hanging ratio recorded 5 fish weighing 1900g and 0.7 hanging ratio caught a total number of 9 fish weighing 3600g. The hanging ratio with 0.7 had the highest relative percentage of number and weight of fish caught followed by 0.5 hanging ratio, the least number and weight of fish caught was recorded by 0.3 hanging ratio. The percentage occurrence of fish species caught in all the hanging ratios pooled together showed that *Citharus citharus*, *Tilapia dageti* and *Chromidotilapia guntheri* were the most abundant species caught and they constituted about 56% of the total weight of fish caught. There was no significant difference ($P>0.05$) in the number and weight of fish caught by the different hanging ratios.

Keywords: Hanging ratios, Multifilament, Gillnet, Kainji Lake

INTRODUCTION

Gillnet is one of the oldest types of fishing gear and is widely used to harvest diverse marine and freshwater species. Gillnets are classified as a passive gear, consisting of a large wall of netting which can be set at or below the surface of the water body. Its construction can be single, double or triple (trammel net) netting. Depending on the operation, gillnet can be drifting, fixed or encircling. A gillnet consists of netting attached between a head-rope and a foot-rope. The net is kept open vertically by the differences in buoyancy between the two ropes. Kainji Lake is becoming depleted (Abiodun 2003) due to overfishing and catching of juvenile fish, thereby, leaving no young fish to grow to adult fish. Therefore, the selectivity of fishing gear and appropriate hanging-ratio is important for the protection of the young individual fish species and the development of appropriate management policies.

Justification of the Study

In Kainji Lake gill nets are popularly known to be use for fishing with different mesh sizes ranges from 38mm, 51mm, 76mm, 89mm to 178mm and hanged at 0.5 hanging ratio without considering efficiency and selectivity of other hanging ratios. Also, based on Baranov's principle of geometric similarity who predicts that the catch process of gillnets is a function of fish size and mesh size only. The size of the mesh will be directly correlated with the size of the species that is being targeted. However, the shape of the meshes is controlled by the hanging ratio (HR). The body shape of the fish will help determine the necessary HR used to capture a particular species. Narrow bodied fish will require a smaller HR, whereas a wide bodied fish will require a larger HR (Gabis *et al*, 2012). Therefore, there is need to experiment on varying hanging ratio and efficiency of the net in Kainji Lake. The study will help to determine the effect of different hanging ratios on catch efficiency of Multifilament gillnet in Kainji Lake.

MATERIALS AND METHODS

Study Location

Operation of the gillnets were carried out at Monia fishing ground, Southern Basin of Kainji Lake. The required meshes in dimension of the gear were calculated: the number of meshes needed for the length and depth were worked out taking into consideration the mesh size and hanging percentage. Computation was based on the formula of Eyo and Isangedighi, (2016):

$$\text{Number of meshes in length of net} = \frac{\text{length of net}}{\text{meshsize} \times \text{horizontal coefficient of hanging (E)}}$$

$$\text{Number of meshes in depth of net} = \frac{\text{depth of net}}{\text{meshsize} \times \text{vertical coefficient of hanging (V)}}$$

Experimental Layout

The nets were ganged together randomly using randomized numbering techniques to form a fleet of 3 gangs of net, based on Eyo and Isangedighi, (2016) method. It is done this way so as to eliminate the possibility of a fish being led to a particular hanging ratio, with three trials at three different strata. The nets were set in the evening (between 6pm - 7 pm) and hauled the following morning (between 6.30am – 7.30am) to determine the fish caught. The catches were carefully removed as the net is hauled into the boat. The catches were then separated according to the hanging ratio that caught them and sorted into their respective species using fish identification keys 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 based on the formula provided by Ahmed, (2005).

$$\text{RSDI} = \frac{\text{Number of species caught by each hanging ratio}}{\text{Total number of species caught by all the hanging ratios}}$$

The data obtained from the work was subjected to descriptive statistic and statistical analysis of variance (ANOVA) using the number and biomass of fish caught by the different hanging ratios.

RESULTS AND DISCUSSION

Catch Composition

A total number of 9 fish species belonging to 4 Families were caught by the experimental gillnets, the species composition of the fish caught shown the effect of size selectivity and efficiency of varying hanging ratio (0.3, 0.5 and 0.7). A total number of 18 Fish weighing 6780g were caught in the entire hanging ratio with 0.7 hanging ratio having the highest number of 9 fish and weight of 3600g followed by 0.5 hanging ratio with 5 fish and weight of 1900g, the least number of fish caught was recorded by 3.0 hanging ratio with 4 fish weighing 1280g. The percentage occurrence of fish species caught by the different hanging ratios pooled together showed that *Citharus citharus*, *Tilapia dageti* and *Chromidotilapia guntheri* were the most abundant species caught and they constituted about 56% of the total weight of fish caught (Tab.1) (Fig. 1 and 2).

Mode of capture and Size of Fish

From the total number of 18 fish recorded the highest Mode of captured of 14 (77.78%) fish were caught by Gilling, 3 (16.67%) fish by Wedging and 1 (5.55%) fish were caught by Entangling (Figure 3). Based the size of fish caught, *Tilapia zilli* was the least size of fish caught with a length range of 12-20cm and weight of 50-200g, *Lates niloticus* was the largest fish caught with a length range of 13.50-60cm and weight of 100-1600g.

The result obtained from the experimental study showed the efficiency of the net, hung at different hanging ratio in catching different species of fish. It was observed that the number, biomass and relative percentage of fish species caught by the three different hanging-ratios showed 70% (E-0.7) hanging-ratio had the highest catch. The reason might be due to the tightly hung net at 70% (E-0.7) which made the net to be less flexible thereby allowing the fish to be gilled. This is in line with the work of Solarin and Kusumiju (2003) who stated that the performance of gillnet was positively influenced by 70%(E-0.7) hanging coefficient and rubber float. However, In the European marine fisheries the lower hanging ratios are applied in flatfish fisheries whereas nets for catching round fish typically have hanging ratios between 0.4 and 0.5. Research

results have indicated that the hanging ratio may affect the selectivity of the nets. Gabis et al. (2012) noted that a decrease in hanging ratio resulted in an increasing number of mainly smaller *Tilapia mosambica* becoming entangled in the net. Similarly, Petriki et al. (2014) found a decrease in selectivity for blue ling when the hanging ratio decreased from 0.6 to 0.4 due to more small specimens being caught in the loosely hanging nets. He, (2006) found that the numbers of large perch increased when the hanging ratio decreased, whereas no changes could be observed in the length frequencies for roach (*Rutilus rutilus*) when changing the hanging ratio. He interpreted the species difference as being due to the fact that the perch were a spiny fish that were entangled more easily when the hanging ratio was decreased.

CONCLUSION.

This project work was carried to ascertain the effectiveness of the different hanging ratios on the catch efficiency of gill net in Kainji Lake using three hanging ratios of 30%(E-0.3), 50%(E-0.5) and 70%(E-0.7). The result obtained showed that 70%(E-0.7) hanging ratio was more effective than other hanging ratios which may be due to the level of tightness and body shape of the fish species caught.

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I give my profound gratitude to the Almighty God for Preserving my Life throughout the duration of the work, my sincere appreciation also go to those who contributed to the success of this work; they include D. Ibrahim, H. Saliu and A. Ibrahim. May God continue to bless you all.

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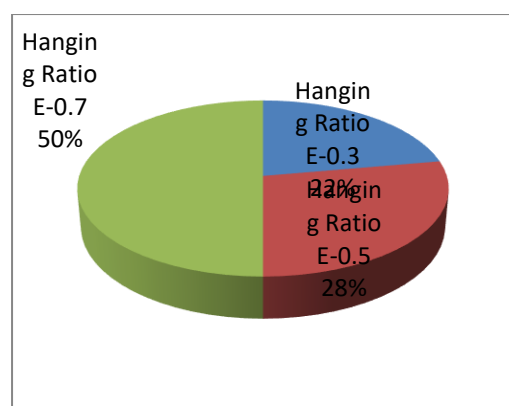


Fig. 1: Relative Percentage of Fish species caught

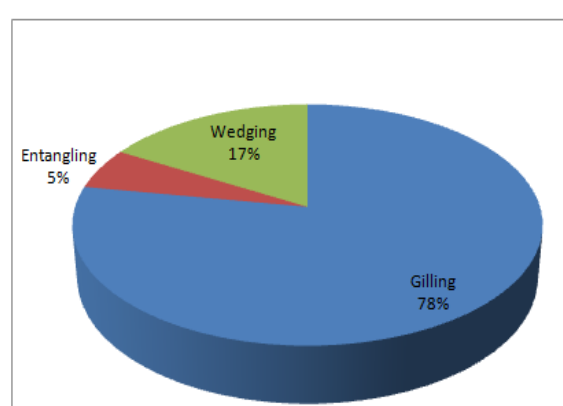


Fig. 3: Percentage mode of capture

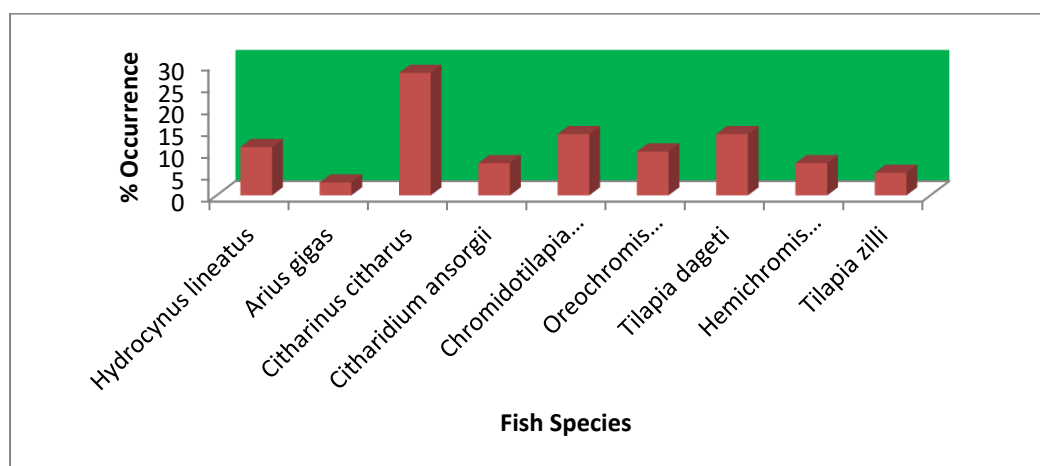


Fig. 2: Percentage occurrence of fish species caught in the entire net Hanging Ratio

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Table 1: Summary of fish species caught by the different Hanging ratio

Species	Hanging Ratio 0.3		Hanging Ratio 0.5		Hanging Ratio 0.7		Total		Percentage (%)	
	No	Wt(g)	No	Wt(g)	No	Wt(g)	No	Wt(g)	No %	Wt(g)%
<i>Hydrocynus lineatus</i>	0	0	0	0	3	750	3	750	16.67	11.06
<i>Arius gigas</i>	1	100	1	100	0	0	2	200	11.11	2.95
<i>Citharinus citharus</i>	1	500	1	450	2	950	4	1900	22.22	28.02
<i>Citharidium ansorgii</i>	0	0	1	500	0	0	1	500	5.55	7.37
<i>Chromidotilapia</i>	0	0	1	500	1	450	2	950	11.11	14.01
<i>guntheri</i>	1	180	0	0	1	500	2	680	11.11	10.03
<i>Oreochromis niloticus</i>	1	500	0	0	1	450	2	950	11.11	14.01
<i>Tilapia dageti</i>	0	0	0	0	1	500	1	500	5.56	7.37
<i>Hemichromis</i>	0	0	1	350	0	0	1	350	5.56	5.16
<i>bimaculatus</i>	4	1280	5	1900	9	3600	18	6780	100	100
<i>Tilapia zilli</i>	22.22%	8.88%	27.78%		50%	53.10%				
Total			28.02%							
Relative Percentage										

FISHING GEARS AND THEIR IMPACTS ON THE ENVIRONMENT AND FISHERIES RESOURCES IN NIGER DELTA REGION, NIGERIA

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Abstract

This paper reviewed the impacts of both active, passive, derelict fishing gears and illegal fishing on Fisheries resources and the environment in the Niger Delta region. The Niger Delta region is one of the most important deltas in Nigeria and it occupies an important position in the fisheries and aquaculture development of Nigeria. The region is naturally endowed and is rich in crude oil, gas, water, wildlife, useful vegetation and human resources. Fisheries resources of the Niger Delta like any of its kind elsewhere in the world contribute to the biodiversity resources of the region. Hence, they are vulnerable to the current state of “worldwide extinction of species”, which makes it very imperative for the fisheries resources of the Niger Delta to be optimally exploited, conserved and managed for sustainability. Fishing gears/materials in the Niger Delta, like elsewhere on the globe has a great influence on the sustainability of the fisheries resources in the area. A catalogue of some commonly fishing gears in the region was reviewed in relation to their impact on fisheries resources and the environment. Recommendations made to help reverse the adverse impacts of fishing gears/materials on fisheries resources include the introduction of new fishing gears and fishing methods to be accompanied by proper inspection and monitoring, enforcement, and protection of the fisheries resources to prevent these resources from depletion and extinction amongst others.

Introduction

The Niger Delta region is one of the most important deltas in the world and it occupies a significant important position in the fisheries and aquaculture development of Nigeria. The region is naturally endowed and is rich in crude oil, gas, water, wildlife, useful vegetation and human resources. It covers relatively several ecological zones such as the sandy coastal ridge barriers, brackish mangrove, freshwater permanent/seasonal swamp forests, and lowland rainforests. Fishing is the major occupation of the people of the Niger Delta (Udo, 1987). The Niger Delta consists of 9 states; Abia, Akwa-Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo and Rivers state. The Niger Delta contributes more than 50% of the entire domestic Nigerian fish supply, being blessed with an abundance of both fresh, brackish, and marine water bodies that are inhabited by a wide array of both fin fish, and non-fish fauna that supports artisanal fisheries (Akankali and Abowei; 2010a).

Fisheries resources are stocks of target species and there is a very high nexus between their ability to thrive cum their conservation and the dynamics of their environment. Fishery resources comprise myriad biological types (examples are plankton, fish and mammal species) that are intractably associated with certain chemical parameters (examples are salinity, dissolved oxygen concentration) and physical parameters (examples are sediment type, oil, and gas reserve, currents, and space) which can be further differentiated by quality and quantity and relational attributes. Fisheries resources of the Niger Delta like any of its kind elsewhere in the world contribute a part to the biodiversity resources of the region. Hence, they are vulnerable to the current state of “worldwide extinction of species”, this makes it very imperative for the fisheries resources of the Niger Delta to be optimally exploited, conserved and managed for sustainability, UNDP/FAO (1996) recognized the need for exploitation and conservation of Nigerian fisheries resources from the inception of the pioneering marine biology research for stock assessment for commercial exploitation. Almost any equipment or gear used for fishing can be termed a fishing material or tackle. Some examples of fishing materials include hooks, lines, sinkers, floats, rods, reels, baits, lures, spears, nets, gaffs, traps, waders, and tackle boxes. Fisheries conservations are those methods and measures concerned with the protection and preservation of fish and other aquatic life, particularly in seawaters. Fishing materials in the Niger Delta have a great influence on the sustainability of the fisheries resources in the area.

Impacts of Fishing Gears on Fisheries Resources and the Environment of Niger Delta, Nigeria.

Fishing not only reduces fish stocks, but excessive fishing pressure can also cause the collapse of fish populations and destabilization of the ecosystem (Gislason *et al.* 2000, Hutchings 2000) and many fishes become vulnerable, endangered, or critically endangered. According to Megwalu *et al.* (2018), the majority of the fishing gear used, either passive or active, has damaging effects on the environment. Illegal fisheries

practices in small-scale fisheries also impede the sustainable development of inland fisheries in the Niger Delta, for example, the use of poisons, explosives, the use of small mesh size fishing nets and other destructive gear, and irresponsible fishing methods and techniques, as well as the use of traps as weirs. These practices have been the root of certain problems associated with decreasing diversity and species decline. Since the inland waters in the Niger Delta are open access for small-scale fisheries, economic problems occur when the number of fishers increases and compete for the exploitation of vulnerable resources. Biologically, the impact of using unconventional fishing gears includes the destruction of the natural habitat and ecosystem that sustain fisheries resources populations; the capture of juveniles and immature fishes before allowing them to grow to commercial sizes; and damage or loss of fish stocks, especially of the most commercially important of target species

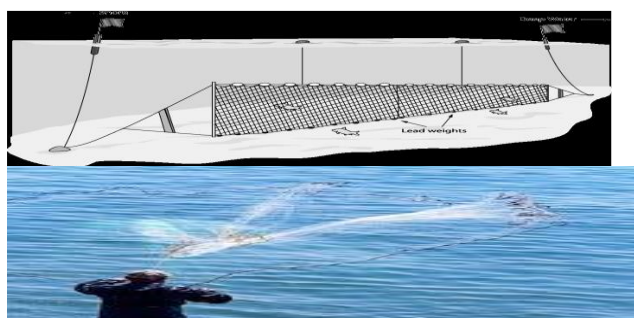


Figure 1a: Fish fence

Plate 1a: Cast net

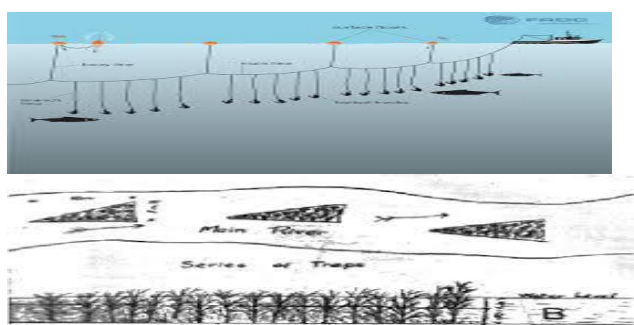


Figure 1b: Long line with hooks

Figure 1b: Fish shelter

Figures and plates 1a to 1d show pictures/diagrams of some of the commonly used fishing gear in the Niger Delta Nigeria

Commonly Used Fishing gears in Niger Delta Region and their Impacts on Environment and Fisheries Resources

Gillnet

- Scott (1966) describes “gillnet as the commonest gear in river fishing in Niger Delta Gill nets are presently a major and popular fishing material widely used for fish capture in the major and minor water bodies in the Niger Delta. They are normally set at sunset and tugged at sunrise. The target fish species for the gill net fishery are Nile Perch (*Lates niloticus*), *Tilapia species*, *Bagrus*, *Clarias*, *Protopterus*, *Alestes*, *Hydrocynus* and many other demersal species. In 1966, Scott describes “gillnet as the commonest gear in river fishing in Niger Delta”. In the Bonny estuary, gill nets comprised more than 50% of the gear deployed by fishers (IPS, 1990 Chinda *et al*, 1994) and also (Solarin *et al*, 2003) reported gill nets as comprising the most abundant small-scale fishing gear in Nigeria. Species selectivity of gillnet includes bycatch of marine mammals, sea birds and turtles. Generally, some of the impact's gillnets have on fisheries resources and the environment are as follows;
- Ghost fishing of lost fishing gear. Gillnets can become lost due to adverse weather conditions or by conflict caused by collision with other fishing gear or vessel traffic. Derelict gear may continue to fish after being lost. (Breen, 1990)
- The benthic effects of a gillnet fishing operation are during its retrieval, at this point, the nets and lead lines are more likely to snag bottom structures or the exposed sedentary benthos. The anchoring system can also affect bottom organisms and structure if they are dragged along the bottom before ascending.

- The net can forcibly tear organisms from the sea bottom or overturn cobble and small boulders organisms may be attached.

Thus, depending on the depth of water, the nature of bottom sediments in the area where gill nets are deployed and the intensity of their use, they can sometimes significantly alter the ecology and environment.

Hand net

A hand net can also be called a scoop net or dip net, this net or mesh basket is held open by a hoop. It may or may not be on the end of a handle. Hand nets have been used since ancient times and can be used for scooping fish near the surface of the water. A hand net with a long handle is often called a dip net. Dip nets can also be used to scoop crabs in shallow water. The basket is made of wire or nylon mesh, rather than cloth mesh, since crabs fight, bite, twist and turn when they are caught. When a hand net is used by an angler to help land a fish it is called a landing net. Hand nets are usually less destructive to fishes and the environment, hence they are often used for temporary capture of fishes for tagging activities and other experimental purposes that require the fish to remain alive in good condition, so they are safely released back into their habitats. However, dip nets and large hand nets are usually deployed by several fishers simultaneously, when used in shallow waters tend to distort the bottom sediments and also sweep both the targeted and non-targeted species, thereby impacting adversely on the environment and the fisheries resources.

Surrounding net

A surrounding net is a fishing net which surrounds fish on the sides and underneath. It is set vertically in the water to surround the school of fish, generally of pelagic nature. It is typically used by commercial fishers and pulled along the surface of the water. There is typically a purse line at the bottom, which is closed when the net is hauled in (Otobo, 1976). Hence, surrounding nets are often synonymous with purse seine nets. The purse seine net is extensively used in Niger Delta regions to target some adult and juvenile species such as *Ethmalosa fimbriata* (Bonga fish) resulting in species decline (Ama-Abasi *et al.*, 2007). Virtually all types of surrounding nets adversely impact the environment and fisheries resources of the region. In most cases, both target and non-target species and even juvenile fish are usually swept indiscriminately by surrounding nets when used. It is an active gear that results in significant mortality of most of its catches and has a heavy by-catch percentage, while at the same time seriously creating turbulence in the environment/ecology of the fishes.

Throw net (Cast net)

A throw net, also known as a cast net, is used in the Niger Delta for fishing. It is a circular net with small weights distributed around its edge. This type of net is cast or thrown by hand in such a manner that it spreads out on the water and sinks. This fishing technique is called net casting or net throwing. Fish are caught as the net is hauled or tugged back in. This simple fishing device is particularly effective for catching small bait or forage fish and has been in use, with various modifications for centuries. Cast nets are used all year round, night and day and the catch per unit effort could be great, though the operation is somehow very exerting (Alegbeleye *et al.*, 2003). Cast nets are selective for lower size ranges and larger faster-moving fish can escape the falling net but may become entangled in the process (Welcomme 2001). Also, the catch of juvenile fish is often inevitable and may be released back into the water either alive or dead. In either situation, the fish biota is usually adversely impacted by the use of a throw net.

Fish Fence

The fish fence is made up of sticks tied together by traditional fibres. Often traditional mats are employed in fish fencing. In Cross-River State, the fence usually stretches the main channel leaving space of a few meters width in the centre to allow canoes and river boat passage. The catching chambers always point downstream, so they could theoretically catch almost all fish which move upstream. Often attached to the catching chamber are detachable large conical traps with non-returning valves. The fisher detaches these traps to collect his catches. Fish fencing within the Cross River basin is seasonal and often used for a few months of the year when the current is very slack and the water shallow. They are usually erected in March each year and dismantled in May. The most common fishes captured by this gear are *Labeo*, *Citharinus*, *Distichodus* and Catfishes. When the water begins to rise in mid-May, the fish fence gives the best results but about a week or two later, the currents become so strong that the traps are either dismantled or abandoned. (Reed *et al.*, 1967). This fishing material is not species selective because, the catching chamber of this fishing material always points downstream, so it could catch almost any fish moving upstream. Although its usage is

seasonal. Furthermore, it oftentimes constitutes a hindrance for fishes that migrates across different water areas to breed. Thus, reducing the breeding potentials of such species across their various breeding seasons.

Trawl gears

A trawl is a tunnel-shaped fishing net which is towed through the water. The water strains out through the mesh entrapping the fish and retaining them in the cod end of the trawl. Historically, Trawling is a new method. Trawling started about 100 years ago. Since then, there has been significant development in terms of methods and equipment, particularly with regard to the size of the trawl and specialization according to the type of species one wishes to catch. Thus, different trawls have developed that are better for a particular type of fish than others. The shape and size of the trawl vary significantly. The main factors taken into consideration when it comes to developing and specializing in trawling include fish behaviour, seabed conditions, selection devices (grating and mesh selection) and the vessel's engine power. The pulling speed during trawling ranges from 1.5 knots to 5 knots. Smaller shrimp trawlers travel at the lowest speed, whereas larger whitefish trawlers and pelagic trawlers travel at the highest speed. Two main uses of trawl have developed: bottom otter trawl and pelagic trawl. In addition, there is a midway solution referred to as a semi-pelagic trawl. In the following, we will describe the characteristics of bottom trawl and pelagic trawl, as well as beam trawl as this type of trawl, deviates significantly from the ordinary trawling concept. The trawling activity pattern using a single bottom otter trawl varies according to several factors such as catch availability, the number of vessels on the field, as well as other circumstances. Trawl gear is a highly active gear that has very serious impacts on fisheries resources and the environment and some of them are as follows

- Bottom trawling may impact the abundance of bioturbators, which affects nutrient fluxes (modified from Olsgard et al., 2008) and can indirectly indicate in which habitat trawling might affect primary production.
- Trawling can have an impact on the sediment structure and fauna of an aquatic environment. It can also cause changes in the relative abundance of bottom fauna.
- Large numbers of fish may be damaged and/or killed by the gear but not caught.
- Trawling can cause damage to vulnerable habitats and species.

Fish Poisons

The use of fish poison is a very bad fishing method and this method is not good for conserving aquatic resources. This method has been prohibited in Nigeria since 1992, but artisanal fishermen of the Niger Delta region still use explosives and poison from time to time in Inland waters to kill, daze or shock fish. Ichthyotoxic plants and synthetic chemicals are used in Nigerian inland. The synthetic chemicals used include Gamalin 20, Aldrex 40, Didimacs 25, Atranex, etc. These synthetic chemicals which are usually in liquid forms are simply poured on the water surface of ponds, rivers and lakes to narcotize and kill fish. The appropriate plant parts such as the bark, leaves or roots are collected from surrounding bushes, they are then prepared and poured into water. The neurotoxic or suffocating effects eventually result in the fish floating (belly up) on the surface of the water bodies, they are then collected with scoop nets or harvesting nets. According to Welcomme (2001), he claimed that most poisons affect the oils of the fish and the flesh is generally safe to eat, although where synthetic chemicals are used residues may accumulate in the fish flesh to toxic levels. Many other benthic organisms may be severely damaged because poisons are indiscriminate. Often these organisms and small fish, which are not desired, are much more vulnerable to the effect of poisons than the target fish. Fish poisons take place mainly in the dry season. Between November and April in waters less than two meters deep (Udolisa and Lebo, 1983). Fish poisons also significantly affect the water quality of any aquatic environment where it is applied.

Explosives

This is in other terms known as blast or dynamite fishing which apart from killing a school of fish, it is also extremely destructive to the surrounding ecosystem that supports the fish. It also means danger for the fishermen as well, with accidents and injuries. The local fishermen find the technique to be easier than the traditional methods used as it results in higher numbers of catches. It involves the use of bombs made with kerosene and fertilizer and the use of locally made dynamites and grenades along riverbanks and mining paddocks. This explosive was first introduced to Nigeria to blast stones (quarrying). Fishing with explosives is very dangerous and extremely destructive, indiscriminately killing all species within the radius of action of the explosion. The dead and dazed fish are then picked up with hands and a scoop net. Human victims of self-made explosives can take months or even years to recover. Fishing with explosives is very dangerous

and extremely destructive, indiscriminately killing all species within the radius of action of the explosion. Its explosion is highly damaging to the benthic communities and branching corals. It converts hundreds of years of coral growth into broken rubble in a second. The use of dynamite in coral reefs results in serious damage to the habitat and the recovery of such habitat is very slow and may take several decades before complete recovery is achieved.

Mosquito nets

Mosquito nets are operated in the creeks, and mud flats on rivers and lagoons. The mosquito nets are operated all year round with peaks in the dry season between October and April. The gear can be 5 to 8 meters long with a depth of 1.5 - 2.5 metres. Depending on the size of the net, it can be operated by a fisherman or two from a canoe or by walking on the mud flat. Since the mesh size of mosquito nets cannot be ascertained and is usually far below the regulatory limits for fishing nets mesh sizes, it catches mostly fry and fingerlings of species of commercial importance, such as *Sardinella sp*, *Ethmalosa fimbriata*, *Penollula sp*, and *Engraulidae*. This of course leads to the indiscriminate sweeping effects of the potential future year classes recruit into the different fisheries of the region. It also has the impact of significantly altering the food chains/webs of aquatic ecology, especially at their lower trophic levels.

Lift Net (Atalla)

Lift net referred to in the local language of some Niger Delta tribes as *Atalla* is an active gear that is usually operated by an individual Fisher. While in use, lift nets are often lowered into the water and spontaneously lifted from the water the moment the Fisher observes the sought-after fish(es) have gathered over them. Lift nets can be installed or attached to a canoe or on the shore of rivers, lagoons, lakes and estuaries. *Atalla* fishing for fingerlings is common among the *Ijaws* and *Urhobo* ethnic group fishers of the Niger Delta region. The construction and size of the net differ, depending on the species targeted and the design preferences of the Fisher. The significant thing about this gear is that very small mesh-size nets (less than 10mm) are generally used (Awachie and Walson, 1978). As a result of the small meshed-sized netting, the *Atalla* catches large quantities of fry, fingerlings and young fish of different species.

Beach seine

A Beach seine is a long net with floats and weights designed for use in the inshore waters adjacent to the beach. It is usually laid in a semi-circle out from the beach around the shoal of fish and then back to the beach. It is then pulled on both sides back to the beach. Since it is a long net, it is often pulled by 16-20 fishermen at a time. Beach seine while in use as an active gear is usually dragged on the seabed and causes direct physical damage to the reef substratum (Carpenter and Alcala, 1977; Gomez et al, 1987) and by-catch. Also, Yem *et. al.* (2007) reported that the beach gear usually targets both adult and juvenile fish and is highly non-selective in terms of the different types of species it catches, thus resulting in species decline. In all cases, it disrupts the bottom sediments and the benthic community, as it is often dragged mostly at the bottom of the water while in use.

Conclusion and Recommendation

Presently, most of the fishery's resources in the Niger Delta are greatly depleted and overfished due to the use of non-conventional fishing materials. Upgrading fishing materials and making them more efficient can increase the risk of further depleting fish resources. Therefore, the introduction of new fishing materials (gears) and fishing methods should be accompanied by proper inspection and monitoring, enforcement and protection of the fisheries resources in order to prevent these resources from depletion and extinction. Also, studies of the technical details and design of common fishing materials in the Niger Delta area should be carried out so as to ascertain their potential effects on the fishery and possible areas of improvement. Enforcement of the required mesh size for fishing materials (nets) for fishing in the Niger Delta waters should be carried out to prevent some of the species from going into extinction. Advocacy and enlightenment amongst fishers to cease the use of obnoxious fishing materials is also highly recommended.

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FISH PARASITOLOGY AND PATHOLOGY

PREVALENCE OF GASTROINTESTINAL PARASITES OF *Parachanna obscura* IN KIRI RESERVOIR, SHELENG, ADAMAWA STATE, NIGERIA

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ABSTRACT

Parasites are a danger for fish even more in natural environment than in farming conditions. Knowledge of their biology is important for prevention, the objective of this study was to investigate the prevalence of gastrointestinal parasitic infection in *Parachanna obscura* in Kiri reservoir, Shelleng, Adamawa State. *P. obscura* species were randomly sampled every month for a period of six months from May to October, 2017. After morphometric measurements, the abdominal cavity of each fish was cut open. The gastrointestinal parts were separated from the other visceral organs and placed in Petri dishes containing physiological saline. The intestine was further carefully slit open to aid the emergence of the parasitic helminths. The distribution of infected *P. obscura* showed that three (3) classes of parasites were identified, these include; trematode (42.11%), nematode (36.84%) and protozoa (21.05%). Out of the 62 *P. obscura* examined, 21 (33.87%) species were infected with a parasite load of 54, and an intensity of 2.57. The females had 15 (44.12%) while the males had 6 (21.43%). The prevalence of parasites in relation to Standard Length showed that the highest infection was recorded in size ranges 18-20.9 cm and 21-23.9 cm with 8 (12.90%) each, while the range 102-127g had the highest infection with 12 (19.35%). There is significant difference between parasite infection and weight (g) at $p < 0.05$. There is prevalence of gastrointestinal parasites in *P. obscura* found in Kiri reservoir.

Keywords: Gastrointestinal Parasites, *Parachanna obscura*, Condition Factor, Kiri Reservoir, Shelleng.

INTRODUCTION

African snakehead, *Parachanna obscura*, is an emerging aquaculture candidate in Nigeria and the sub-Saharan region as a whole. The species is preferred for its palatable fillet and strong flesh integrity (Ama-Abasi and Ogar, 2013) and because that species is high in protein and fat contents thereby making it a good healing agent for post operation patients (Adegbehingbe and Umezurike, 2018). It is a piscivorous/predatory fish which lives in the bank vegetation of the main river channel or in the vegetated (swampy) areas in the flood plain, pools and lagoons (Olasunkanmi and Ipinmoroti, 2014). In the Eastern part of Nigeria, a number of gastrointestinal helminth worms have been reported to be present and isolated from this fish by Ogbulie *et al.* (2003). The occurrence of *Camallanus* species, *Capillaria* species, *Acetodoxtra* species, *Clinostomum* species, *Diplostomum* species and *Polyonchobothrium* species has been documented. Parasites are the most common pathogens the aquaculturist will encounter (Ogbulie *et al.*, 2003). Parasitological studies are therefore very important in the development of fisheries potential of freshwater habitat. This present study investigates the parasitic helminth fauna of common Snakehead fish, *P. obscura* from Kiri Reservoir, Shelleng, Adamawa, Nigeria.

MATERIALS AND METHODS

The study area was Kiri Reservoir in Shelleng Local Government Area of Adamawa State, Nigeria. It is located within; Longitude 9° 40' 47" N 12° 00' 51" E. The reservoir was built by damming the Gongola River to provide irrigation to Savannah Sugar Company (SSC) a large-scale sugarcane plantation and processing company set up as a joint venture between the Nigerian Federal Government and the Commonwealth Development Corporation (CDC), London (Figure 1). The reservoir is 11.2km long, 20m high zoned embankment, with an internal clay blanket. The reservoir was completed in 1982 (Institute of Civil Engineers [ICE], 1990). The reservoir has a capacity of 615m³ (Enplan, 2004).

Sampling of *Parachanna obscura*:

Fish specimens were procured from artisanal fishers at the landing site for the study, this was done twice a month for a period of six months from May to October, 2017. The fishers used a wide range of fishing gear such as hook and line, long line, cast nets, gill nets and traps. On the landing site, fish specimens were randomly sorted and identified using keys and descriptions by Idodo-Umeh, (2003). Both male and female species were bought and conveyed immediately to the laboratory in plastic containers with ice-block for laboratory analysis on the same day as they were bought. A total of 62 species were sampled for this study.

Laboratory analysis

In the laboratory, the Total Length (cm) of each fish was taken using a measuring ruler to the nearest 0.1 cm. Standard Length (cm) for each fish was taken to the nearest 0.1 cm. The total body weight in grams was measured for each fish sample to the nearest 0.01 g using a top loading Mettler balance (Mettler Toledo-ML204T). The sex of *P. obscura* was determined after dissection by the presence of testes or ovaries (Imam and Dewu, 2010). The gastrointestinal tract of each fish sample was dissected from the rectum to the oesophagus and all helminths seen were carefully detached, processed using standard parasitological methods as described by Olurin and Samorin (2006). The parasites obtained were counted and placed in normal saline overnight in a refrigerator and later fixed in 5% formalin later.

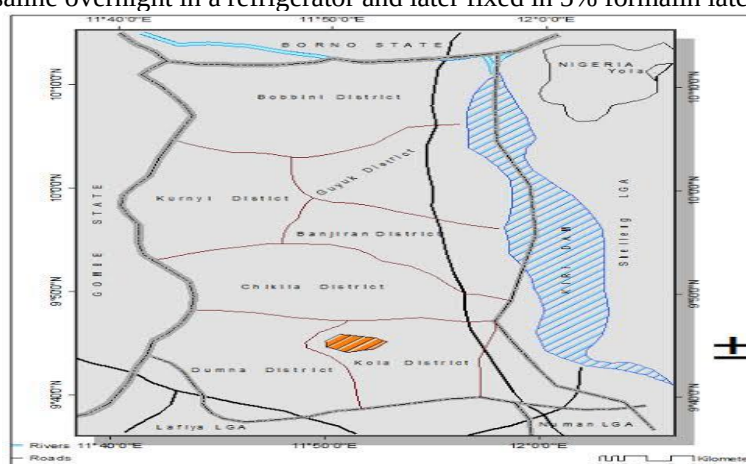


Figure 1: Map of Kiri Reservoir, Shelleng Local Government in Adamawa state.

They were stained overnight with Ehrlich's haematoxylin solution and passed through graduated alcohol levels (30, 50, 70, 90 % and absolute) for 45 minutes to dehydrate, cleared in xylene and mounted on a glass slide in Canada balsam for examination and identification under the light microscope at x10 as described by Uneke, (2015). The identification of parasites collected was done according to the key of identification by Paperna, (1996).

The prevalence of parasites infection was calculated as;

$$\text{Prevalence (\%)} = \frac{\text{Number of host infected}}{\text{Total number of host examined}} \times 100\%$$

Intensity of parasite was estimated as;

$$\text{Intensity} = \frac{\text{Total number of parasites species in a sample of fish examined}}{\text{Total number of fish host infected}}$$

The prevalence of parasite infection base on sex of fish was estimated as;

$$\text{Prevalence (\%)} = \frac{\text{Number of a particular sex of fish infected}}{\text{Total number of a particular sex of fish examined}} \times 100\%$$

RESULTS AND DISCUSSION

The distribution of recovered parasites showed that three (3) classes of parasites were recovered. The distribution of parasites species from these classes revealed one species of parasites for each class, which are; *Posthodiplostomulum* minimum having a load of 24, *Procamallanus* sp. with 21 parasite and Cyst of *Myxobolus* sp. having a Parasite load of 12 (Table 1). Out of the 62 *P. obscura* that was examined, 21 (33.87%) species were infected with a Parasite Load of 54, having an intensity of 2.57 In relation to sex of the species infected; the females had 15 (44.12%) while the males had 6 (21.43%). The Chi square test

showed that there was however significant difference in the prevalence of parasite infection in *P. obscura* by sex ($P > 0.05$, $\chi^2 = 3.67$, $df = 2$) in Kiri Reservoir (Table 2).

The prevalence of parasites in relation to Standard Length showed that the highest infection was recorded in size ranges 18-20.9 cm and 21-23.9 cm with 8 (12.90%) each, the size ranges 24-26.9cm and 27-29.9cm had the least, with 1 (1.61%) each. The Chi square test showed that there was no significant difference in the prevalence of parasite infection in *P. obscura* by Standard Length ($P > 0.05$, $\chi^2 = 3.96$, 10df) in Kiri Reservoir (Table 3). The distribution of parasites prevalence in relation to Weight showed that the weight ranges 102-127g had the highest parasite infection of 12 (19.35%) while, the weight range of 128-153g had the least with 3 (4.84%) The Chi square test showed that there was however significant difference in the prevalence of parasite infection in *P. obscura* by weight ($P < 0.05$, $\chi^2 = 29.43$, $df = 6$,) in Kiri Reservoir (Table 4)

Table 1: Distribution of Parasites Recovered from *P. obscura* Species

Class	Parasite species	Parasite Load	Percentage (%)
Trematode	<i>Posthodiplostomulum minimum</i>	21	42.11
Protozoa	Cyst of <i>Myxobolus sp.</i>	12	21.05
nematode	<i>Procamallanus sp.</i>	21	36.84
Total		54	100

Table 2: Prevalence of Parasites in Relation to Sex of *P. obscura*

Sex	No Examined	No. Infected	<i>Posthodip</i>	<i>Myxobol</i>	<i>Procamal</i>	Parasite Load (%)
Male	28 (45.16%)	6 (21.43%)	8 (38.10%)	4 (33.33%)	4 (19.05%)	16 (29.63)
Female	34(54.84%)	15 (44.12%)	13 (61.90%)	8 (66.67%)	17 (80.95%)	38 (70.37)
Total	62 (100%)	21 (33.87%)	21 (100%)	12 (100%)	21 (100%)	54 (100)

$\chi^2 = 3.67$, $df = 2$, $p > 0.05$

Table 3: Prevalence of Parasites in Relation to Standard Length (cm) of *P. obscura*

Stand. Length (cm)	No. examined	No. infected (%)	Parasite Load	Intensity
12 – 14.9	1	-	-	0
15 – 17.9	14	3 (4.84)	8	2.7
18 – 20.9	18	8 (12.90)	22	2.8
21 – 23.9	25	8 (12.90)	20	2.5
24 – 26.9	3	1 (1.61)	2	2.0
27 – 29.9	1	1 (1.61)	2	2.0
Total	62	21 (33.87)	54	2.6

$\chi^2 = 3.96$, $df = 10$, $p > 0.05$

Table 4: Prevalence of Parasites in Relation to Weight (g) of *P. obscura*

Weight (g)	No. examined	No. infected (%)	Parasite Load	Intensity
50 -75	14	-	-	0
76 -101	9	6 (9.68)	25	4.2
102 -127	32	12 (19.35)	20	1.7
128 -153	7	3 (4.84)	9	3.0
Total	62	21 (33.87)	54	2.6

$\chi^2 = 29.43$, $df = 6$, $p < 0.05$

The main factors determining the distribution of fish parasites; prevalence, intensity and abundance of infection in aquatic environments are, the diet of the host, the life span of the species, mobility of the host throughout its life; and a variety of habitats encountered, its population density and the size attained (Laguerre *et al.*, 2011). The prevalence and intensity of infection in the present study is significantly lower when compared with the reports of Oden *et al.* (2015) that examined a total of 510 specimens of *P. obscura* and reported 53.9% prevalence of infection with a mean intensity of 8.0 in the Great Kwa River. But it's however higher than the report of Akinsanya *et al.* (2010) who reported 5.9% prevalence of helminth parasites from 340 specimens that were subjected to parasitological examinations in Lekki Lagoon, Lagos these differences could be due to the sample size or period of the research study. Generally, the prevalence, and abundance of

parasitic infection showed that more females are infected than the male species. A similar report was observed by Akinsanya *et al.* (2010) who reported that the female species were infected with a prevalence of 7.2% while the male species had a prevalence of 5.2%, Bolaji *et al.* (2011), reported 56.97% females and 43.03% males. But a contradictory the record was reported by Oden *et al.* (2015) who recorded that males carried more nematodes than females owing to the territoriality of the male species. However, Rohde (1993) reported that endoparasites infect the two sexes differentially because male and female fish often have different feeding habits. The number of *P. obscura* infected in the present study depend on the size of the fish within the limit of samples analyzed. This is similar to the findings of Obiekezie and Ekanem (1995) who reported severe infection and damage caused by *Trichodina maritinkae* to the population of *Heterobranchus longifilis* fry. Akinsanya *et al.* (2010) who reported that the length groups 21-25cm had a prevalence of 6.25%, while the highest length groups 26-30cm recorded zero prevalence of infection. A different observation was reported by Oden *et al.* (2015) who reported that there was no correlation between nematode infection and the size of *P. obscura*. The occurrence of *Clinostomum metacercaria* as reported by Ogbulie *et al.* (2003) in River State, Akinsanya *et al.* (2010) also reported *Clinostomum metacercariae* from *P. obscura* obtained from Lekki lagoon, Lagos, Nigeria. Akinsanya and Hassan (2002a) also reported *Clinostomum metacercariae* from Cichlids purchased at Eleyele River, Ibadan, Nigeria. Ogbulie *et al.* (2003) isolated *Camallanus* species, *Capillaria* species, *Acetodoxtra* species, *Clinostomum* species, *Diplostomum* species and *Polyonchobothrium* species from cultured *P. obscura*. Akinsanya and Hassan (2002b) examined the excystment of the encysted *metacercariae*. Yakubu *et al.* (2004) in a comparative study of gut helminthes of *Tilapia zillii* and *Clarias gariepinus* from River Uke, Plateau State, Nigeria reported *Camallanus* species, *Procamallanus laeviconchus*, *proteocephalid* species, and *Sphaerostoma bramae*. This was not recorded in the present study. The occurrence of *Procamallanus* species in *P. obscura* in the present study is in conformity to the work done by Yakubu *et al.* (2004)

CONCLUSION

This study has established incidence of gastrointestinal infection in *Parachanna obscura* of the Kiri Reservoir. Though, the intensity of infection is low and does not pose a threat to its aquaculture. There is significant difference in infection amongst the sexes and various size classes

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PARASITE PREVALENCE OF *CLARIAS ANGUILLARIS* FROM RIVERS BENUE AND MU, MAKURDI, BENUE STATE, NIGERIA

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ABSTRACT

Parasite prevalence of 200 samples of *Clarias anguillaris* comprising of 100 samples each from Rivers Benue and Mu was evaluated using standard parasitological examination. Out of the 200 samples from both locations, 118 samples were infested with an overall prevalence of 59.00%; while River Benue accounted for 31.00%, River Mu recorded 28.00%. Three genera and species of parasites; cestode (*Diphillobothrium lactum*), nematodes (*Eustrongylides tubifex*) and protozoa (*Ichthyophthirius multifiliis*) were recovered from samples of *C. anguillaris* that were examined. Out of the 59.00% prevalence recorded, Nematodes (*Eustrongylides tubifex*) recorded the highest (25.00%), the least (15.00%) was recorded for Cestodes (*Diphillobothrium lactum*). The prevalence of infection according to the size of *C. anguillaris* examined indicated that the big fish samples had the higher infection (44.00%) compared to the small fish (15.00%). There was significant difference ($p < 0.05$) in the prevalence rate between the age groups. Out of the total samples of *C. anguillaris* examined, the prevalence of infection was higher in the female (33.50%) compared to the males (25.50%). There was significant difference ($p < 0.05$) in the prevalence rates between the sexes. Out of the 118 infected *C. anguillaris* examined, cestode (*Diphillobothrium latum*) and nematodes (*Eustrongylides tubifex*) were found in the intestines and stomachs (cestodes = 8.50% in the intestine and 6.50% in the stomach; Nematode = 17.50% in the intestine and 11.50% in the stomach), protozoa (*Ichthyophthirius multifiliis*) was found on the skin and gills (5.50% on the skin and 9.50% on the gills). On the sites of recovery, while intestine had the highest prevalence of infection (26.00%), the least (5.50%) was recorded for skin.

Keywords: Parasite prevalence, *Clarias anguillaris*, River Benue, River Mu, Cestode, Nematode, Protozoa

INTRODUCTION

Fish plays a vital function in the economic development of any fish producing country. It is considered a cheap source of high quality nutritive animal protein (Ibrahim *et al.*, 2014). Irrespective of the vital role of fish, they are not devoid of parasites which constitute one of the major problems to their health. Parasites of fish have been a great concern since they often bring about a host of disease conditions in fishes and these diseases often weaken of the hosts' immune system thereby increasing their vulnerability to other secondary infections (Eyo and Iyaji, 2014). The effects of these diseases result to nutritive and economic devaluation of fish and fish loss. In order to obtain healthy and quality fish meat, it is important that the fish should be free from all types of pathogens like bacteria, protozoans, helminthes and annelids.

Several studies have been done on parasites of fish in some water bodies in Nigeria (Kawe *et al.*, 2016; Simon-Oke, 2017; Onyishi and Aguzie, 2018). Due to the paucity of information on parasite prevalence of *Clarias anguillaris*, which is one of the most fish consumed in Makurdi, this study is aimed at evaluating the prevalence of parasites of *Clarias anguillaris* from Rivers Benue and Mu, Benue State, Nigeria.

Materials and Methods

The study took place in Makurdi the capital of Benue State, Nigeria, located at longitude 7°43 N and latitude 8°32 E (Wikipedia, the free encyclopedia).

Sample collection and preparation

A total of 200 samples of *C. anguillaris* comprising of 100 samples each of different sizes were randomly bought from Rivers Benue and Mu, Makurdi, Benue State, Nigeria, respectively. The fish samples were transported in two clean plastic containers containing water to the Fisheries and Aquaculture Laboratory, Joseph Sarwuan Tarka University, Makurdi for parasitological examination after they were being gently immobilized. They were identified based on external features as described by Edeh and Solomon (2016). The sexes of fish were identified by physical observation of the urogenital papillae located behind the anus, which is long or distended in males but round and reddish in the matured female as described by Lagrue *et al.* (2011). The length of each fish sample was measured from the tip of the snout to the end of the caudal fin using a calibrated meter rule to the nearest centimetre (cm) and recorded. Fish samples were also weighed to the nearest gram (g) using an weighing balance (Golden Mettler, Model: GW: 1.3kg, NW; 1kg - US and recorded.

Parasitological examination

External examination of each of the fish for parasites was carried out using the technique of Emere and Egbe (2006) on the gills and skin. The skin and gill of each of the fish were firstly examined for ectoparasites using hand lens. Thereafter, skin smear of the fish samples were made and placed on a petri-dish and 3 ml of 0.9% saline solution were added and stirred using a mounted pin. Some drops of the mixed solution were collected using dropper, placed on a slide, and then covered with a cover slip after which, observation on a light microscope was made. The gills of each of the fish were dissected using a dissecting kit, each of the gills were placed in 10 ml of normal saline in petri-dish, later removed and then place on a slide on which 1-2 drops of saline solution were added and observed under a light microscope

Examination of endo parasites was by the techniques of Bichi and Dawaki (2010). An incision was made on the ventral side of the fish from the anal opening to the lower jaw using scalpel blade to expose the internal organs. The Stomachs and intestines were aseptically removed and dissected to reveal contents and washed into petri-dishes with normal saline. Parasites collected were identified using their distinctive body shapes and morphological features. Resuscitated parasites were grouped and identified using taxonomic guides by Paperna (1996), counted and recorded.

Statistical Analysis

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Descriptive statistics like percentage was used to express prevalence while chi-square test was used to compare the association between variables and a statistically significant association between variables was considered at $p < 0.05$.

Results and Discussion

The overall prevalence of infection of *C. anguillaris* based on location of sample collection is shown in Table 1 while Table 2 shows the prevalence of parasite of *C. anguillaris* from Rivers Benue and Mu.

From Table 1, out of the 200 samples of *C. anguillaris* comprising of 100 samples each from both locations, 118 samples were infested with an overall prevalence of 59.00%; while River Benue accounted for 31.00%, River Mu recorded 28.00%

From Table 2, three genera of parasites; cestode (*Diphilobothrium lactum*), nematodes (*Eustrongylides tubifex*) and protozoa (*Ichthyophthirius multifiliis*) were recovered from *C. anguillaris*. Out of the 59.00% prevalence recorded, while Nematodes recorded the highest (25.00%) the least (15.00%) was recorded for Cestodes.

Table 1. Overall prevalence of infection of *C. anguillaris* based on location of sample collection

Samples location	Number of fish examined	Number infested	Number not infested	Prevalence
River Benue	100	62	36	31.00
River Mu	100	56	44	28.00
Total	200	118	82	59.00

Table 2. Prevalence of parasites of *C. anguillaris* from Rivers Benue and Mu

Parasite groups	Number of fish examined	Number infested	Prevalence
Cestode (<i>D. lactum</i>)	200	31	15.50
Nematode (<i>E. tubifex</i>)	200	50	25.00
Protozoa (<i>I. multifiliis</i>)	200	37	18.50
Total	200	118	59.00

The relationship between prevalence of infection and size of fish, prevalence of infection and sex of *C. anguillaris* from Rivers Benue and Mu are shown in Table 3 while Table 4 shows the prevalence of infection of *C. anguillaris* in relation to the sites of attachment. The prevalence of infection according to the sizes of *C. anguillaris* examined indicated that the big fish samples had the higher infection (44.00%) compared to the small fish (15.00%). There was significant difference ($p < 0.05$) in the prevalence rate between the size groups as indicated in Table 3.

Also from Table 3, out of the total samples of *C. anguillaris* examined, the prevalence of infection was higher in the female (33.50%) compared to the males (25.50%). There was significant difference ($p < 0.05$) in the prevalence rates between the sexes.

In Table 4, out of the 118 infected *C. anguillaris* examined, while cestode (*Diphilobothrium latum*) and nematode (*Eustrongylides tubifex*) were found in the intestines and stomachs (cestodes = 8.50% in the intestine and 6.50% in the stomach; Nematode = 17.50% in the intestine and 11.50% in the stomach), protozoa (*Ichthyophthirius multifiliis*) was found on the skin and gills (5.50% on the skin and 9.50% on the gills). Generally, of the infected body parts, while intestine had the highest prevalence of infection (26.00%), the least (5.50%) was recorded for skin.

Table 3. Relationship between prevalence of infection and size, parasite prevalence and sex of *C. anguillaris* from Rivers Benue and Mu.

Parameters	Number of fish examined	Number infested	Prevalence	P-value
Size				
Small fish (1-5 cm)	67	30	15.00	0.4826
Big fish (5.1-10cm)	133	88	44.00	
Total	200	200	59.00	
Sex				
Female	107	67	33.50	0.0258
Male	93	51	25.50	
Total	200	118	59.00	

Table 4. Parasite prevalence of *C. anguillaris* in relation to the sites of attachment

Parasite groups	Site of attachment	Number infested	Prevalence
Cestode (<i>D. latum</i>)	Intestine	17	8.50
	Stomach	13	6.50
Nematode (<i>E. tubifex</i>)	Intestine	35	17.50
	Stomach	23	11.50
Protozoa (<i>I. multifilis</i>)	Skin	11	5.50
	Gills	19	9.50
Total		118	59.00

Understanding of the spread and prevalence of parasites of wild fish is a recipe for formulation of effective control or elimination strategy for improving the health standard of human and profitable fish farming in Nigeria, hence this study has attempted to shed more light on the prevalence and distribution of *C. anguillaris* and the parasite groups infecting them in Rivers Benue and Mu State Nigeria. The results of this study revealed 59.00% overall prevalence rate of three genera of parasites in the *C. anguillaris* sampled from the two rivers in Benue State, Nigeria. The high prevalence recorded in this study is consistent with reports of Omeji *et al.*, (2022), Oghenochuko *et al.*, (2020) and Oyedineke *et al.*, (2010) who reported prevalence of 59.30%, 52.90% and 59.20%, respectively but higher than the prevalence (42.70%) recorded by Dauda *et al.*, (2016) for *Tilapia zilli* in Gombe markets and (47.12%) by Goselle *et al.* (2008) in Jos. The variations in the rate of infection could be due to the abiotic and biotic factors of the rivers where the fish samples were collected for parasitological study. This observation is in agreement with the reported work of Thompson and Larsen (2004). Nematodes (*E. tubifex*) were found to be the most prevalent parasites in the infected *C. anguillaris* compared to cestode (*D. latum*) and protozoa (*I. multifilis*) in this study. This finding is in agreement with the previous reports by Osimen and Anagha (2020) who reported higher prevalence of nematode from fresh water fishes from rivers in Edo State, Nigeria Goselle *et al.*, (2008) who reported higher prevalence of gastrointestinal nematode (36.5%) compared to trematode (33.1%) and cestode (30.4%) in *Tilapia zilli* in Jos and Olofintoye (2006) who also reported higher prevalence of nematodes (32.6%) compared to cestodes (11.1%) in *Tilapia zilli* in Ekiti. This suggests that variations in prevalence of infection from one habitat to the other could be a function of host - parasite relationship and abiotic factors such as dissolved oxygen, temperature and pH (Amaechi, 2014). The reported work of Nimbalkar and Deolalikar, (2015) has also shown that parasites especially, the helminths are mostly found in fresh water fishes where factors such as parasite species and its biology, host and its feeding habitats, physical factors, hygiene of the water body and presence of intermediate hosts contribute to their prevalence and intensity.

The present study showed that bigger *C. anguillaris* had the higher parasite infection than the smaller ones. This finding is consistent with the reported work of Dauda *et al.*, (2016) and Goselle *et al.*, (2008) who

reported higher prevalent rate of gastrointestinal helminths in the adults of *Tilapia zilli* compared to the juveniles. Differences in the prevalence of infection between sizes may be due to changes in their type of diet from weeds, seeds, phytoplanktons and zooplankton in juveniles to insect larvae, crustacean and worm in adult fishes (Amare *et al.*, 2014)

The higher prevalence recorded for female fish compared to the male counterpart from this study could be due to the physiological state of the females as most gravid females in the farm could have had reduced resistance to infection by parasites; this is because the immune system of the females is highly compromised during pregnancy. This agrees with the reported work of Ayuba *et al.* 2016, Ogonna *et al.*, (2017) and Solomon *et al.*, (2018) but disagrees with the findings of Kawe *et al.*, (2016) Afolabi *et al.* (2020) who reported higher prevalence in male *C. gariepinus* than the female.

Organ specificity of parasites infection in this study showed that the intestine is the most preferred organ for the recovered parasites in most infected fish samples. This finding could be due to the fact the stomach acts as a temporary food storage cavity while most digestion activity occurs in the intestine, which could probably result in the release of the ova/cysts of parasites in the food the fish swallow. This assertion agrees with the reported work of Dauda *et al.*, (2016).

CONCLUSION

There can be higher infestation and prevalence of the parasites encountered in this study in same or other host fish species, but adoption of adequate hygiene and integrated management will reduce their prevalence

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HISTOPATHOLOGY OF GILLS AND LIVER TISSUES OF THE FRESHWATER FISH *Oreochromis niloticus* (LINNAEUS 1758) EXPOSED TO *Tamarindus indica* SEED HUSK POWDER

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ABSTRACT

The effects of exposures to acute tamarind seed husk powder concentrations on Nile tilapia (*Oreochromis niloticus* L.) were determined with respect to histology. The experiments were conducted for 96 hours and with six different tamarind seed husk concentrations (control, 1.2, 1.4, 1.6, 1.8 and 2.0 mg/l). Fish exposed to different tamarind seed husk concentrations displayed histopathologic alterations in the gills and liver. Gill tissues displayed edema in the filamentary epithelium, lifting of lamellar epithelia, hyperplasia of the epithelium with fusion of adjacent lamellae and necrosis in primary and secondary lamellae. Liver tissue revealed cloudy swelling, disarrangement of hepatic cords, deformed and atrophied hepatocytes with shrunken displaced nuclei, aggregation of nuclei due to loss of cell boundaries, vacuolation of hepatocytes, congestion of blood in the blood vessels and haemorrhages were observed. The investigation demonstrated the necessity to regulate the discharge of tamarind seed husk powder effluents from domestic and industrial sources into aquatic systems

Keywords: Histopathology, tamarind seed husk powder, *Oreochromis niloticus*, gills, liver

INTRODUCTION

The contamination of environment with heavy metals has become a source of concern not only because their threats to aquatic organisms but also due to public health implications of such pollutants. Histopathological alterations are biomarkers of effect of exposure to environmental stressors, revealing prior alterations in physiological and/or biochemical function (Hinton *et al.*, 1992). Fish is a suitable indicator for monitoring environmental pollution because they concentrate pollutants in their tissues directly from water and also through their diet, thus enabling the assessment of transfer of pollutants through the trophic web (Boon *et al.*, 2002).

Tamarindus indica (Local name: *Tsamiya*), Family Fabaceae, Subfamily Caesalpinioideae is an important food in the tropics. Virtually every part of the tree (wood, roots, leaves, bark, husk and fruits) is of a significant value in the subsistence of rural people as well as a number of commercial applications. Tamarind fruits are versatile as they can be used for many purposes. The unique sweet or sour flavour of the pulp is popular in cooking and flavouring (El-Siddig *et al.*, 2006). Jena (1991) reported seed husk of tamarind as a useful piscicide containing saponin like ingredient with strong haemolytic properties in *Cyprinus carpio*. At about 5-10 ppm, tamarind seed husk powder killed *Channa marulius* and *Cyprinus carpio* effectively, in addition to major carps within 2-3hours. The Nile tilapia *Oreochromis niloticus* is a deep-bodied fish with cycloid scales, silver in colour with olive, grey or black body bars, it often flushes red during the breeding season, grows to a maximum length of 62 cm, weighing 3.65kg, surface-feeding omnivore fish belonging to the family Cichlidae.

MATERIALS AND METHODS

Experimental fish

One hundred and eighty (180) *O. niloticus* (mean weight, 19.56 ± 0.7 g and mean length, 12.42 ± 0.3 cm) juveniles were used for the study; the fish were purchased from a reputable fish farm from Kano, Kano State.

Experimental site

The experiment was conducted at the Fish Hatchery Laboratory, Department of Fisheries and Aquaculture, Bayero University, Kano, Nigeria.

Source and Processing of Tamarind seed husk

The tamarind seed husk was collected within the premises of Bayero University Kano, and authenticated at the Department of Forestry and Wildlife Management, Bayero University, Kano. The seed husk was removed from the pod and air-dried to a constant weight at (27°C). The dried samples were grounded into fine powdered and sieved through 0.25mm sieve.

Experimental Design

A completely randomized design was used for the experiment. A total of one hundred and eighty (180) juvenile of *Oreochromis niloticus* were randomly distributed into the plastic containers (60cmx40x40cm) size and 70 litres capacity at a stocking rate of 10 fish. The eighteen (18) tanks were assigned to 5 treatments with (control inclusive).

Definitive Test

Results from range finding tests provided guide for the concentration level to be used in definitive test. The definitive test was carried out by filling eighteen (18) plastic tanks with 20 litres of water each. The test was carried out using concentration of tamarind seed husk powder earlier determined from range finding test. The concentrations used were 1.2mg, 1.4mg, 1.6mg, 1.8mg and 2.0mg of tamarind seed husk powder per litre of water (mg/l) for *Oreochromis niloticus*. The different concentrations were prepared using sensitive weighing balance. The response of the fish to slight stimuli was used as an index of toxicity while non-response of the fish to tamarind seed husk powder estimated to be lethal to 50% of the test organism after 96 hour of exposure.

Histological studies

Histological experiment was carried out in the Department of veterinary Nursing Department, Ahmadu Bello University, Zaria, Kaduna State. At the end of the experiment, one fish per treatment, that is three fish per concentration were sampled after 96hour exposure. The organs were fixed in 10% formalin for three days after which the tissue was dehydrated in periodic acid Schiff's reagent (PAS) following the methods of (Hughes and Perry, 1976) in graded levels of 50, 70, 90 and 100% alcohol for three days, to allow paraffin penetrates it. A gill arch of the right side of each fish was collected and fixed in Bouin's fluid for 24 hours,

dehydrated in graded ethanol concentrations and embedded in paraffin wax. Sagittal sections (5µm of thickness) were cut and mounted on glass slides. Sections were deparaffinized in xylene, hydrated in ethanol and stained with hematoxylin-eosin (H&E). The liver was quickly dissected, sliced into 3 mm thick slabs, and immersed in Bouin's fixative for 24 hours, dehydrated, and embedded in paraffin; a minimum of 5 pieces resulted. Histological sections (5 µm of thickness) were cut and stained with H&E. Changes induced by treatment in the gills and liver tissues were photographed and analyzed by light microscopy.

STATISTICAL ANALYSIS

Data were analysed using Minitab 14 for summary of statistics in water quality parameter. The mean lethal concentration (LC₅₀) for 96 hours was computed using probit analysis (Finney, 1971).

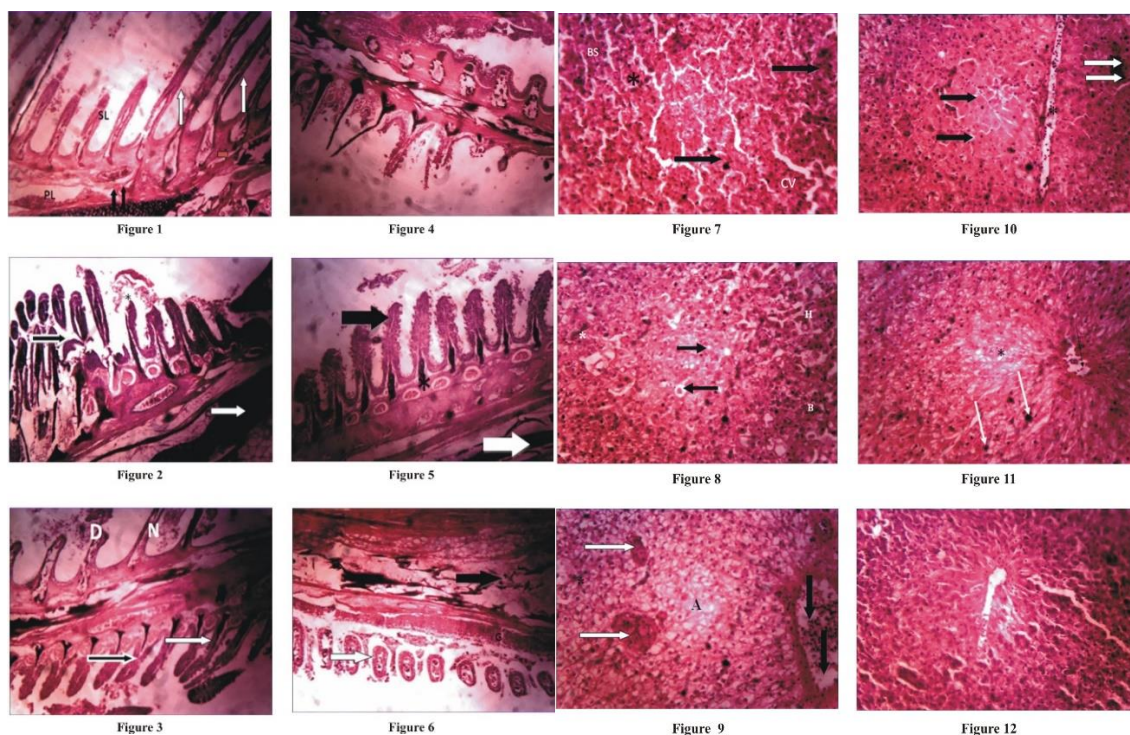
RESULTS AND DISCUSSION

The results presented in Table 1 summarized the histological changes observed in Nile tilapia exposed to different concentrations of TSH powder. Histopathological changes in the gills and liver were observed for all the treatments. Lesions were essentially similar for all treatments and exposure time, although the intensity of cell damage increased with increasing concentration and time of exposure. The normal histology of the gill structure of *Oreochromis niloticus* exposed to 0 mg/l of TSH powder is shown in Figure 1. Following the exposure to Tamarind seed husk powder, changes in histological structure were noted particularly in the filament and lamellae in (Figure 2-6). This corroborates with the observation of Strivastava and Strivastava (1994) who reported that teleosts accumulate lead (Pb) both directly from diet and indirectly from the aqueous medium through cutaneous aquatic food chain and through the lamella surface. Alterations like epithelial lifting, hyperplasia and hypertrophy of the epithelial cells, besides partial fusion of some secondary lamellae are examples of defense mechanisms, since; in general, these result in the increase of the distance between the external environment and the blood and thus serve as a barrier to the entrance of contaminants. As a consequence of the increased distance between water and blood, the oxygen uptake is impaired (Isiyaku *et. al.*, 2015).

Table 1. Histological changes observed in Nile tilapia exposed to different concentrations of Tamarind seed husk

Constant. (mg/l)	GILLS	LIVER
0.00	Normal gills no pathological lesion observed	Normal liver no pathological lesion observed
1.20	half of the gill arch have it filament and lamellae degenerated	Disarrangement of hepatic cords, deformed and atrophied hepatocytes
1.40	Hypertrophy of the gill arch, degenerated gill filament and lamellae	Fibrosis, rapture of hepatocytes, haemorrhages and vacoulation of cytoplasm
1.60	central parts of the gill arch have both the lamellae and filament degenerated	Cytoplasmic vacuolation, bile pigment disintegration and eosinophilic granules
1.80	High degenerated lesion observed at the gill arch, filaments, and lamellae	hepatic tissue showing focal necrosis, bile stagnation and cytoplasmic degeneration
2.00	Hypertrophy of gill arch and degenerated gill filament	Disarrangement of hepatic cords, shrunken and displaced nuclei

Figure 7 shows the normal liver cell no pathological lesion observed in the control fish. The present study also demonstrates that the liver of control fish exhibits a normal architecture and there were no pathological abnormalities. The hepatocytes present a homogenous cytoplasm and a large central or subcentral spherical nucleus. The histopathological appearance of liver following exposure to tamarind seed husk powder showed important alterations which comprise of hypertrophy of hepatocytes, nuclear hypertrophy, blood congestion in the central veins, as well as the diffusion of melanomacrophages in the parenchymal tissues of liver. It revealed that the increase of tamarind seed husk powder caused cytoplasmic vacuolation, cellular necrosis in the parenchymal tissue, cellular degeneration, damage of nuclei, bile stagnation in addition to congestion in the blood sinusoids and decreasing in the number of hepatocytes nuclei of hepatic tissue. Disarrangement of hepatic cords, deformed and atrophied hepatocytes with shrunken, displaced nuclei, aggregation of nuclei due to loss of cell boundaries, vacuolation of hepatocytes, and congestion of blood in the blood vessels in Figure 8 exposed to concentration of 1.2ml/g of TSH powder treated fish. Fibrosis, rupture of hepatocytes, haemorrhages and vacuolation of cytoplasm (Figure 9) was recorded in concentration of 1.4 mg/l of tamarind seed husk powder. Cytoplasmic vacuolation, bile pigment disintegration and eosinophilic granules in the cytoplasm (Figure 10) were observed in concentration of 1.6 mg/L of tamarind seed husk powder treated fish. Figure 11 shows liver with hepatic tissue showing focal necrosis, bile stagnation and cytoplasmic degeneration in concentration of 1.8 mg/l of tamarind seed husk powder treated fish. Disarrangement of hepatic cords, shrunken and displaced nuclei and vacuolation of hepatocytes were observed in the highest concentration of 2.0mg/l (Figure 12). This result is similar to the work of Wade *et al.* (2002) and Fagbenro and Adebayo, (2005), who worked on the toxicity varying toxicants on *Oreochromis niloticus*.



A) Microphotograph of the gills

B) Microphotograph of the Liver

CONCLUSION AND RECOMMENDATION

The current study reinforces the application of histopathology as a powerful tool for monitoring anthropogenic contamination within aquatic environments. Histopathological analysis showed morphological alterations in gills, liver and kidney of tamarind seed husk powder-exposed fishes revealing differences in the types and severity of lesions according to increases in exposure time. These results are important in establishing a direct correlation between tamarind seed husk powder accumulation and

morphological damage, and therefore help to characterize the mechanism of tamarind seed husk powder-induced pathogenesis. The investigation demonstrated the necessity to regulate the discharge of tamarind seed husk powder effluents from domestic and industrial sources into aquatic systems.

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ENDOPARASITIC HELMINTHS OF *CITHARINUS CITHARUS*, *HYDROCYNUS FOSKALII*, *SCHILBE MYSTUS*, AND *AUCHENOGLANIS OCCIDENTALIS* FROM, MAKURDI LOWER BENUE RIVER

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ABSTRACT

Endoparasitic helminth of *Citharinus citharus*, *Hydrocynus foscarii*, *foscarii*, *Schilbe emystus* and *Auchenoglanis occidentalis* from Lower River Benue was determined using standard parasitological methods. The fishes were rendered inactive by cervical dislocation prior to parasitological examination. Two parasites (*Eustrongylides* sp. and *Diphillobothrium latum*) were recovered from the fish. The intestine had higher parasitic infestation compared to the stomach. Variation in the percentage parasite load with respect to the size range (total length) of the fish species existed. For *Citharinus citharus*, while fish with length group of 175.4 – 200.4 cm had the highest percentage parasite infestation (48.15%), the least (7.41%) was recorded for length groups of 125.2 – 150.2 and 200.5 – 225.5, respectively. For *Hydrocynus foscarii*, while the range in total length of 230.70 – 280.70 had the highest percentage parasite infestation (62.50%), the least (37.50%) was recorded for range in total length of 180.60-230.60. For *Schilbe mystus* while the range in total length of 128.22-178.22 had the highest percentage parasite infestation (29.41%), the least 9.80%

was recorded for range in total length of 228.24-278.24cm and for *Auchenoglanis occidentalis*, while the range in total length of 317.83 had the highest percentage parasite infestation (31.65%), the least 16.46%) was recorded for range in total length of 217.81-267.81cm. Generally, bigger fish samples had higher percentage parasite load than the smaller ones. Between the sexes of the fish species, female fish samples were more infested with higher percentage parasite load of 59.26%, 75.00%, 64.71% and 46.84% for *C. citharus*, *H. forskalii*, *S. mystus* and *A. occidentalis* than the male with percentage parasite load of 40.74%, 25.00%, 35.29% and 53.16% for *C. citharus*, *H. forskalii*, *S. mystus* and *A. occidentalis*, respectively.

Keywords: Fish parasite, *Eustrongylids* sp., *Diphillbothrium latum*, *Citharinus citharus*, *Schilbe mystus*, and *Auchenoglanis occidentalis*

Introduction

Fish is an important food affordable source of animal protein with a very long list of dietary and health benefits. (Tossaviet *et al.*, 2014). Fishing is a means of livelihood for many people; some countries earn foreign exchange and overcome food shortages faced by their growing populations through fish farming (Otooret *et al.*, 2016). Parasitic diseases are not only a limitation to fish production but also a big problem to consumers of fish, especially in areas where freshwater fish are eaten raw or without sufficient processing. Fish parasites often have detrimental effect on fish tissues and often reduce fish growth, yield, aesthetic value, marketability, palatability and reproductive potential (Owolabi, 2008), hence posing a major threat to fish culturists. Fish parasites from one fish can infect others in the same water body, and have zoonotic-infect on humans and animals that eat raw or improperly prepared fish meat (Fagbenro *et al.*, 1993). A number of cases of zoonotic diseases caused by fish parasites have been reported (Khalil *et al.*, 2014). There is little or no information on the parasites of *Citharinus citharus*, *Schilbe mystus*, and *Auchenoglanis occidentalis* from Lower River Benue. The present study aimed at evaluating the endoparasitic helminths of *Citharinus citharus*, *Hydrocynus foscarii*, *Schilbe mystus*, and *Auchenoglanis occidentalis* from Lower River Benue and bridging the existing paucity of information on their helminth parasites.

Materials and Methods

Sample Collection and Identification

Specimens of *C. citharus*, *H. foscarii*, *S. mystus*, and *A. occidentalis* were purchased from the local fishermen at Wadata landing site, Makurdi, lower Benue River and transported to the Fisheries laboratory, Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University, Makurdi, Benue State, Nigeria where they were sorted out into different sizes. Sex determination as well as length and weight measurements were done in line with methods described earlier by Idodo-Umeh (2003). The sexes of fish were identified by physical observation of the urogenital papillae, the total length of each fish was measured to the nearest 0.1 cm using a meter rule mounted on a dissecting board, while the weight was taken in grams to the nearest 0.1g using an electronic weighing balance. The fishes were immediately subjected to parasitological examinations.

Gastrointestinal Parasite Examination

The fishes were rendered inactive by cervical dislocation for easy handling prior to dissection. Cuts were then made on the ventral and lateral sides of the fish to expose the visceral organs. The intestines and stomachs of the fish were removed and processed for parasite recovery. The observation of the recovered helminth parasites was done following recommendations by MAFF (1971). The parasites from different sites were picked, counted, and recorded before fixing in 70% alcohol. Whole mount preparations of the parasites were then made. The parasites were stained for identification by placing in Ehrlich haematoxylin for 5 minutes and then counter stained in alcohol eosin for 1 minute after washing in 70% acid alcohol. The stained parasites were dehydrated in absolute alcohol and cleared in xylene before mounting in Canada balsam. The lactophenol method of Franklin and Goodey (1949) was used for all groups of parasites. Microscopic examination was done using dissecting microscope (X40 magnification) and photomicrographs were taken. Identification of the parasites was done using the keys by Bjoernet *et al.* (2011)

RESULTS AND DISCUSSION

Endohelminth parasites recovered from each of the studied species with respect to the site of recovery are shown in Table 1 while Table 2 shows the number/percentage parasite species per body parts of each of the fish species. *Eustrongylides* sp. was recovered from the stomach of *C. citharus*, *S. mystus*, and *A. occidentalis* while *Diphillbothrium latum* was recovered from the intestine of *C. citharus*, *H. foscarii*, *S. mystus* and *A. occidentalis*.

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out of the 27 parasites recovered from *C.citharus*, while *Eustrongyloids species* accounted for 62.96% in the stomach, *D. latum* accounted for 37.04% in the intestine. 8 parasites were recovered from *H. foskalii* ; these parasites were all found in the intestine. Of the 51 parasites recovered from *S.mystus*, while *Eustrongyloids species* accounted for 25.49% in the stomach, intestine recorded 11.75%. Also, *D. latum* accounted for 15.69% in the stomach, intestine recorded 47.06%. Of the 79 parasites recovered from *A.occidentalis*, while *Eustrongyloids species* accounted for 39.24% in the stomach, intestine recorded 15.19%. Also, while *D. latum* accounted for 8.86% in the stomach, intestine recorded 36.37%. Generally, it was observed that intestine of the species had higher percentage parasite infestation compared to the stomach

Table 1. Parasite species recovered from each of the studied fish species with respect to site of recovery during the study period

Fish species	Parasite	Site of recovery
<i>C. citharus</i>	<i>Eustrongylides sp</i>	Stomach
	<i>Diphillobothrium latum</i>	Intestine
<i>H .foskalii</i>	<i>Diphillobothrium latum</i>	Intestine
<i>S. mystus</i>	<i>Eustrongylides sp</i>	Stomach
	<i>Diphillobothrium latum</i>	Intestine
<i>A. occidentalis</i>	<i>Eustrongylides sp</i>	Stomach
	<i>Diphillobothrium latum</i>	Intestine

Table 2. Number/percentage parasite species per body parts of each of the fish species

Fish species	Parasite species	No (%) of parasites/ body of the infected fish		No (%) of parasite per fish
		Stomach	Intestine	
<i>C. citharus</i>	<i>Eustrongyloids species</i>	17 (62.96%)	0	
	<i>D. latum</i>	0	10 (37.04)	27 (16.36)
<i>H. foskalii</i>	<i>D. latum</i>	0	08 (100)	08 (4.85)
<i>S. mystus</i>	<i>Eustrongyloids species</i>	13 (25.49)	06 (11.75)	
	<i>D. latum</i>	08 (15.69)	24 (45.10)	51 (30.91)
<i>A. occidentalis</i>	<i>Eustrongyloids species</i>	31 (39.24)	12 (15.19)	
	<i>D. latum</i>	07 (8.86)	29 (36.71)	79 (47.88)
Total				165 (100)

The number/percentage parasite infestation of the studied fish species with respect to their total length (cm) are shown in Table 3 while Table 4 shows the percentage parasite infestation of the sexes of the studied fish species during the period of study.

From Table 3, for *C.citharus*, while the range in total length of 175.4 – 200.4 had the highest percentage parasite infestation (48.15%), the least (7.41%) was recorded for range in total length of 125.2 – 150.2 and 200.5 – 225.5, respectively. For *H. foskalii*, while the range in total length of 230.70 – 280.70 had the highest percentage parasite infestation (62.50%), the least (37.50%) was recorded for range in total length of 180.60-230.60. For *S.mystus* while the range in total length of 128.22-178.22 had the highest percentage parasite infestation (29.41%), the least 9.80%) was recorded for range in total length of 228.24-278.24cm

and for *A.occidentalis*, while the range in total length of 317.83 had the highest percentage parasite infestation (31.65%), the least 16.46%) was recorded for range in total length of 217.81-267.81cm.

From Table 4, it was generally observed that the infested female fish samples (2 of *C. citharus*, 2 of *H. forskalii*, 16 of *S.mystus* and 15 of *A. occidentalis*) had higher percentage parasite load of 59.26%, 75.00%, 64.71% and 46.84% for *C. citharus*, *H. forskalii*, *S. mystus* and *A. occidentalis*, respectively than the infested male (2 of *C. citharus*, 9 of *H. forskalii*, 8 of *S.mystus* and 12 of *A. occidentalis*) with percentage parasite load of 40.74%, 25.00%, 35.29% and 53.16% for *C. citharus*, *H. forskalii*, *S. mystus* and *A. occidentalis*, respectively.

Table 3. Number/percentage parasite infestation of the studied fish species with respect to their total length (cm)

Fish Species	Range in Total Length	No (%) Parasites per Range
<i>C.citharus</i>	100.1 – 125.1	4 (14.81)
	125.2 – 150.2	2 (7.41)
	150.3 – 175.3	0 (0)
	175.4 – 200.4	13 (48.15)
	200.5 – 225.5	2 (7.41)
	225.6 – 250.0	6 (22.22)
<i>H.foskali</i>	80.40 – 130.40	0 (0.00)
	130.5 – 180.50	0 (0.00)
	180.6 – 230.60	3 (37.5)
	230.7 – 280.70	5 (62.5)
	280.8 – 380.80	0 (0.00)
<i>S.mystus</i>	28.20 – 78.20	8 (15.69)
	78.21 – 128.21	11 (21.57)
	128.22 – 178.22	15 (29.41)
	178.23 – 228.23	12 (23.53)
	228.24 – 278.24	5 (9.80)
<i>A.occidentalis</i>	167.80 – 217.80	22 (27.85)
	217.81 – 267.81	13 (16.46)
	267.82 – 317.82	19 (24.05)
	317.83 – 367.83	25 (31.65)

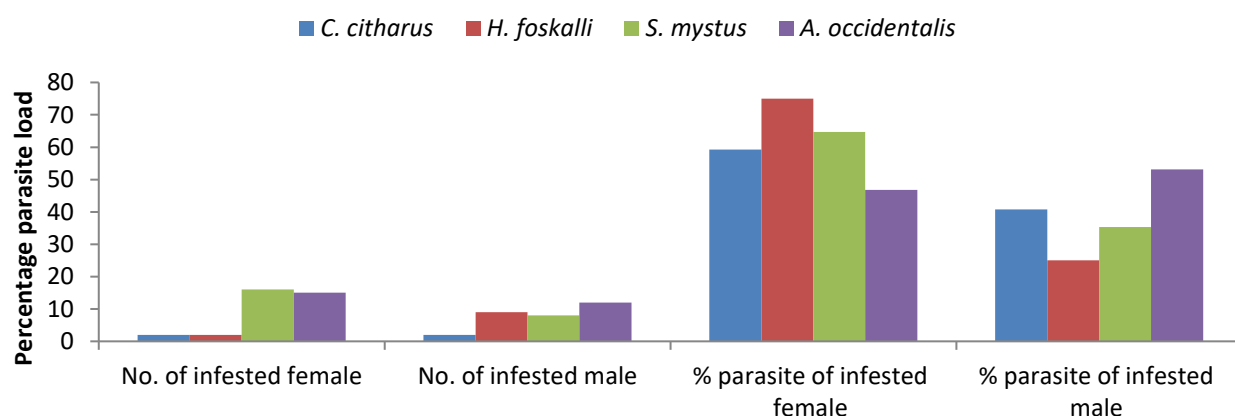


Figure 1: Parasites prevalence of *Citharinus citharus*, *H. forskalii*, *S. mystus* and *A. occidentalis* from lower Benue River

Endoparasitic helminths of *C.citharus*, *H. foskali*, *S.mystus* and *A. occidentalis* were determined for a period of 3 months. Two parasite species (*Eustrongylides sp.* and *D. latum*) were recovered from the studied fish

species except for *Hydrocynus forskalii* where only one parasite species (*D. latum*) was recovered. Recovery of these species of parasites is not surprising as they have been previously recovered from same and other species of fish. Ayuba *et al.*, (2016) Omeji *et al.*, (2018) recovered *D. latum* and *Eustrongylides sp* from the stomach and intestine of *Heterotis niloticus* and *S. resupinata*, respectively from Rivers Mu and Benue. Highest number of parasites was harboured in the intestine compared to the stomach of the fish. The presence of these parasites in the intestine than the stomach might be due to the presence of digested food present there or due to greater surface area present in the intestine. Highest number of parasites in the intestine compared to the stomach of the infested fish agrees with the earlier reports by Sidney *et al.*, (2014), who reported that most digestive activities occur in the intestine, resulting in the presence of absorbable food nutrient on which nematodes depend.

It was not surprising to find *Eustrongylides sp* in the studied fish species sampled from River Benue because of the presence of aquatic birds around the river. Omeji *et al.*, (2013) reported that aquatic birds are important in the ecology of fish parasites because most helminths complete their life cycles in the host birds which in the course of predating on the fish or by reason of migration release same into the water body that inhabit the fish. Prevalence of parasitic infection according to the size (total length) of studied fish species showed an increased infection in bigger fishes than smaller ones. The recorded highest infection rates in bigger fishes compared to the smaller ones could be due to their great search for food and survival needs. This finding is in contrast with the reported work of Ekanem *et al.*, (2011) who revealed highest infection rate in lower length class (smaller fish).

Female fishes were observed to be more infested with higher parasites than the male counterpart. The higher infestation rate of the female fish compared to the male could be attributed to the physiological state of the females and their increased rate of food intake to meet their food requirements for the development of their egg might have exposed them to more (Solomon *et al.*, 2018).

RECOMMENDATION AND CONCLUSION

Although there are no reported cases of fish zoonosis in Nigeria, Public awareness should be conducted on zoonotic nature of fish parasites and danger of consumption of raw or undercooked fish. With increase in aquaculture practices, it is also essential to have facilities for diagnosis and treatment of fish diseases.

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BACTERIAL LOAD OF *CLARIAS GARIEPINUS* FROM A REPUTABLE FARM IN JOS, PLATEAU STATE, NIGERIA

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ABSTRACT

The bacterial load and species diversity of *Clarias gariepinus* from the concrete and earthen ponds of a reputable fish farm in Jos, Plateau State, Nigeria was evaluated using standard method. The total bacteria observed in *C. gariepinus* from earthen pond (34.51×10^5) was significantly higher ($p < 0.05$) than the total bacteria observed in *C. gariepinus* from the concrete pond (33.36×10^5). The bacterial count on the skin of *C. gariepinus* from the earthen pond (12.48×10^5) and (12.03×10^5) on the gill from the concrete pond showed significant variations ($p < 0.05$), with higher indices when compared with the gill and intestine from the earthen pond; skin and intestine from the concrete pond, respectively. The bacterial flora of *C. gariepinus* recovered from the two culture media were almost the same with the Gram negative rod shaped bacteria dominating the of the entire bacteria population. *Eshcherichia coli* was positive to indole production as against all the other detected organisms that tested negative. *Staphylococcus epidermidis* was the most prevalent (50.00%) among the bacteria isolates detected in *C. gariepinus* from earthen pond while the least was recorded for *K. pneumonia* (2.00%). On the other hand, while *Enterobacter. aerogenes* was the most prevalent (44.00%) among the bacteria isolates from the concrete pond, *Klebsiella pneumoniae* was the least (1.33%). The presence of the species of bacteria detected in this work is not surprising as they are considered as the normal flora of all living organisms including fish. The presence of these organisms in the studied fish from the two culture media showed that the media were contaminated. Nonetheless, it is important to ensure that fish products are properly processed before consumption to ensure adequate reduction of zoonotic incidence.

Keywords: Bacteria load, species diversity, *Clarias gariepinus*, Fish farm, Earthen and Concrete ponds, Jos

Introduction

In developing and developed countries of the world, both the poor and rich feed on fish diet or supplement on daily basis (Olagbemide, and Akharaiyi 2019). In many regions where carbohydrate-based foods is the food of choice for many due to poverty, fish is the common source of protein as they are readily available, affordable in markets and trapped in many surrounding streams and rivers (Olagbemide, and Akharaiyi 2019).

Among the living organisms that are associated with warm water aquaculture are microbes which not only influence water quality but are also known to be closely associated with the physiological status as well as

the postharvest quality of fish (Al-Harbi and Uddin, 2003); thus, fish health and its yield are dependent on the quality of the water where they inhabit.

The presence of bacteria in fish could play diverse roles, some of which might be beneficial to the fish. In the earlier studies of Egerton *et al.* (2018), and Butt and Volkoff (2019) microorganisms present in the gut of fish perform a host of functions such as fermenting unused energy substrates, supporting the immune system, preventing growth of harmful species, regulating the development of the gut and producing vitamins for the host. Thus, bacteria can contribute positively to the fish wellbeing. On the other hand, the presence of some bacterial species could lead to post harvest spoilage and adverse health conditions in farmed fishes. Also, in certain conditions some microbes are capable of causing transmitting diseases to the host (Feldhusen, 2000). Thus, intestinal micro flora may be significant in fish spoilage as well as being able to transmit many of the established food borne microbial infections and intoxications. There had been paucity of information on the microbial load of *Clarias gariepinus* Plateau State Nigeria, however this is important for the improvement of fish health especially, *Clarias gariepinus* that is commonly consumed by both the rich and the poor in their diets. Therefore, this study aimed at evaluating the bacterial load and species diversity *Clarias gariepinus* from a reputable fish farm in Jos. Plateau State, Nigeria.

Materials and Methods

Source of Experimental Fish

40 fish samples comprising of 20 samples each of male and female *Clarias gariepinus* were collected live from a reputable fish farm in Jos, Plateau State, Nigeria and transported in plastic containers by road within four to five hours to the laboratory of the Department of Biological Sciences, Joseph Sarwuan Tarka University (formerly known as University of Agriculture), Makurdi.

Sample Preparation, Culture and Isolation of Bacteria

Two external parts (skin and gills) and an internal organ (intestines) of *C. gariepinus* were used for this study. Ten (10) grams from each part of the fish sample was homogenized in 90 ml of distilled water. The homogenate was allowed to settle for 10 minutes prior to the withdrawal of 5 ml of the supernatant for 10-fold serial dilution. One ml of the diluted sample was inoculated using pour plate technique. 0.5 % Nutrient agar medium was poured at 40°C on the plates. The sample and the medium were properly mixed, allowed to set and incubated at 25°C for 48 hours. The colonies were subcultured to get pure cultures which were further screened for the presence of indicator organisms (Effiong and Isaac 2019). Microbial assay of the skin, gills and intestine of experimental fish were carried out to determine the microbial load, identification and frequency of occurrence as described by Cheesbrough (2000). Plates with colonies ranging between 50 – 200 cfu/ml were selected for determination of total bacterial count and isolation of individual bacterial groups. Total load of bacteria was estimated according to Cheesbrough (2000) as thus:

$$\text{Total load of bacteria (cfu/ml)} = \frac{C \times D \times 10 \times V}{W}$$

Where: C= Number of colonies found, D= Dilution factor, V= Volume of physiological saline, W= Weight of the material (fish parts).

Characterization of Bacteria

Morphological characteristics (shape, size and color) of the bacterial colonies were observed visually with the help of naked eyes. Shape of the individual isolate was determined by Gram staining method with the

young culture. The motility test was performed by hanging drop method (Effiong and Isaac 2019). Biochemical tests such as catalase activity, oxidase, indole production, gelatin liquefaction and proteinase test were performed using bacterial isolates from fresh culture according to the methods described by Barrow and Feltham (1993).

Data Analysis

Data collection for bacterial counts were subjected to descriptive statistics and differences in bacterial load and species were analyzed using one-way analysis of variance (ANOVA) at 95 % probability level using SPSS version 20.

RESULTS AND DISCUSSION

The bacterial counts from the isolates from gills, intestine and skin of *C. gariepinus* from earthen and concrete ponds of a reputable fish farm from Jos are shown in Table 1 while Table 2 shows the primary characterization of different bacterial isolates from *C. gariepinus* from earthen and concrete ponds of the reputable fish farm from Jos. The biochemical tests for the various bacterial isolates are presented in Table 3 while Figure 1 shows the percentage of prevalence of bacterial isolates of *Clarias gariepinus* from the reputable farm, Jos.

From Table 1, the total bacteria observed in *C. gariepinus* from earthen pond (34.51×10^5) was significantly higher ($p < 0.05$) than that observed in *C. gariepinus* from the concrete pond (33.36×10^5). The bacterial count on the skin of *C. gariepinus* from the earthen pond (12.48×10^5) and gill (12.03×10^5) from the concrete pond showed significant variations ($p < 0.05$), with higher indices when compared with the intestine.

From Table 2, the bacterial flora of *C. gariepinus* recovered from the two culture media were almost the same with the Gram negative rod shaped bacteria dominating the of the entire bacteria population.

From Table 3, while all the other detected organisms tested negative, *E. coli* was positive to indole production as against the other organisms.

From Figure 1, *S. epidermidis* was the most prevalent (50.00%) among the bacteria isolates detected in *Clarias gariepinus* from earthen pond while the least was recorded for *K. pneumonia* (2.00%). On the other hand, while *E. aerogenes* was the most prevalent (44.00%) among the bacteria isolates from the concrete pond, *K. pneumoniae* was the least (1.33%).

Table 1: Microbial population of the body parts of *C. gariepinus* from earthen and concrete ponds from a reputable far, Jos

Bacteria counts(cfu/ml)	Concrete pond			Earthen pond		
	Gills	Intestine	Skin	Gills	Intestine	Skin
Total heterotrophic bacterial Counts (THBC)						
Total coliform count (TCC)	2.75	2.59	2.75	2.65	2.37	2.55
Faecal coliform count (FCC)	2.32	2.04	2.25	2.49	2.59	2.90
<i>Salmonella shigella</i> count (SSC)	2.75	1.92	2.61	2.67	2.74	3.15
<i>Pseudomonas</i> count (PC)	2.04	1.50	2.05	1.50	1.50	2.20
<i>Staphylococcus</i> count (SC)	2.17	1.50	2.12	2.02	1.50	2.04
Sub total	12.03	9.55	11.78	11.33	10.70	12.48
Grand total	(33.36)			(34.51)		

Table 2: Primary characterization of different bacterial isolates of *Clarias gariepinus* from a reputable farm, Jos

Organisms	Grs	Shp	Mt	Ca	St	Co	Ur	Ox	Fr	Gl	Su	Ma	Mn	Ga
<i>E. coli</i>	-	Rod	+	+	-	-	-	-	-	Ag	-	ag	ag	-
<i>S. enterica</i>	-	Rod	+	+	-	-	-	-	-	A	-	a	ag	-
<i>E. aerogenes</i>	-	Rod	+	+	-	-	-	-	-	Ag	ag	ag	ag	-
<i>B. cereus</i>	+	Rod	+	+	+	-	-	-	A	A	-	a	-	a
<i>S. epidermidis</i>	+	Rod	-	+	-	+	-	-	ag	A	a	a	ag	A
<i>P. vulgaris</i>	-	Rod	+	+	-	-	+	-	ag	A	ag	a	-	Ag
<i>K. pneumoniae</i>	-	Rod	+	+	+	-	-	-	-	A	-	ag	ag	-
<i>P. aeruginosa</i>	-	Rod	+	+	-	-	-	+	ag	A	ag	-	ag	A
<i>S. sonnei</i>	-	Rod	+	+	-	-	-	-	-	Ag	ag	ag	ag	A

Grs = gram stain, Shp = shape, Mt = motility, Ca = catalase, St = starch, Co = coagulase, Ur = urease, Ox = oxidase, Fr = fructose, Gl = glucose, Su = sucrose, Ma = maltose, Mn = manitol, Ga = galactose, - = Negative, + = positive, a = Acid, ag = acid gas, r = rod

Table 3: Biochemical characteristics of bacterial isolates of *Clarias gariepinus* from a reputable farm, Jos

Bacteria isolates	Citrate test	Gelatin	Reaction of bacteria isolates to; Indole production	H ₂ S production test	Proteinase test
<i>E. coli</i>	-	-	+	-	+
<i>S. enteric</i>	+	-	-	+	+
<i>E. aerogenes</i>	+	-	-	-	+
<i>B. licheniformis</i>	+	-	-	-	+
<i>S. epidermidis</i>	+	-	-	-	+
<i>P. vulgaris</i>	-	-	-	+	+
<i>K. pneumonia</i>	-	-	-	-	+
<i>P. aeruginosa</i>	+	-	-	-	+
<i>S. sonnei</i>	-	-	-	-	+

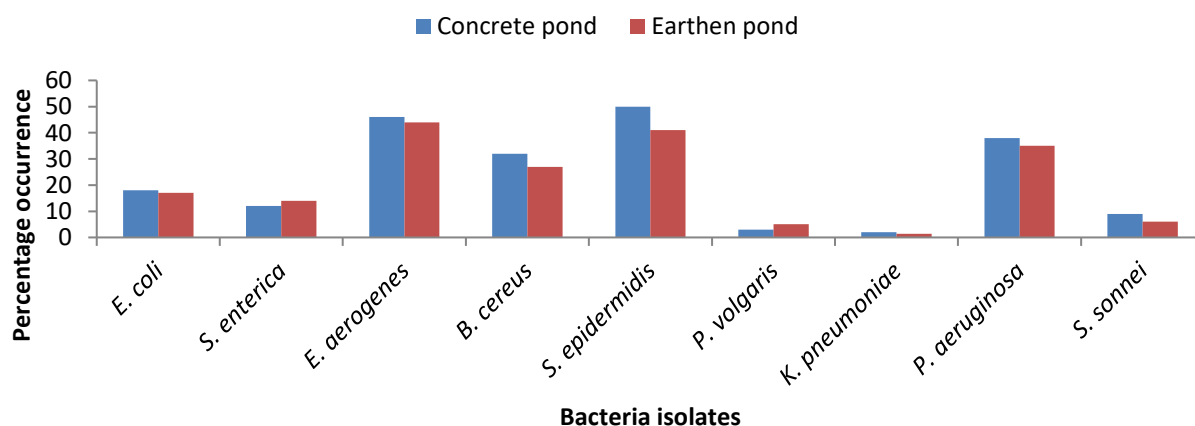


Figure 1: Percentage of occurrence of bacterial isolates of *Clarias gariepinus* from a reputable farm, Jos.

The bacterial counts from the various parts of *C. gariepinus* in this study were observed to be highest on the skin followed by the gills from both culture media. The highest bacteria counts on the skin and gills of the fish samples could be attributed to the constant interaction of these two body parts with the water environment. Although difficult to estimate and compare, studies have shown bacterial population in similar ranges (Austin, 2006; Merrifield and Rodiles, 2015). Bruijn *et al.* (2018), reported fish skin typically harbors 10² -10⁴ bacteria per cm², whereas the gills harbour 10³ -10⁶ bacteria per gram of tissue based on fish species, environment and cultivation methods. The lowest bacterial counts of 9.0 × 10² as observed in the intestine. The low bacterial population in the intestine can be attributed to the anaerobic condition around the gastrointestinal tract that will only support the growth or proliferation of anaerobic or facultative bacteria only (Ashlee *et al.*, 2008).

The bacteria isolates from *C. gariepinus* in this study have been previously detected in same fish or other fish species elsewhere (Adegunloye and Sanusi, 2019; Effiong and Isaac 2019). Jimoh *et al.* (2009) reported similar species in the gut sections of wild and cultured *C. gariepinus* in Abeokuta, Nigeria and Emikpe *et al.* (2011) on skin and in stomach of *C. gariepinus* and *Oreochromis niloticus* from Ibadan, Nigeria and concluded that the occurrence of these species in different organs of fish may be associated with some predisposing factors such as poor handling, feed and feeding, improper pond management, and excessive amounts of decomposing organic matter in the pond (Ampofo and Clerk, 2010). The microorganisms associated with fish or their tissues are usually dictated by the environment where the fish inhabit (Ekpo, 2012; Dehler *et al.*, 2017). Many researchers (Okaeme, 2006, Bruijn *et al.*, 2018) have isolated different species of bacteria from the skin of fresh water fish including *Bacillus* species from the skin of sea water fish. Sugita *et al.* (1997) reported that *Staphylococcus spp.*, *Escherichia coli* were isolated frequently from the skin of fresh water fish; other researchers (Adegunloye and Sanusi, 2019) concluded that predominant genera are *Pseudomonas*, *Staphylococcus* and the member of the family Enterobacteriaceae on the skin of fresh water fishes. The predominance of *S. epidermidis* in this work agrees with the reported work of Adegunloye and Sanusi, (2019) but disagrees with the findings of Effiong and Isaac (2019) and Sugita *et al.* (1997).

CONCLUSION

The presence of the species of bacteria detected in this work is not surprising as they are considered as the normal flora of all living organisms including fish. The presence of these organisms in the studied fish from the two culture media showed that the media were contaminated. Nonetheless, it is important to ensure that fish products are properly processed before consumption to ensure adequate reduction of zoonotic incidence.

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OCCURRENCE OF PARASITES IN *Clarias Gariepinus* FROM UPPER RIVER BENUE VALLEY AREA. YOLA, ADAMAWA STATE

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ABSTRACT

Parasitic infections of fish are of particular importance in the tropics. Various parasites are associated with *Clarias gariepinus* in the wild and cultured environment where they cause morbidity, mortality and economic losses. This study was conducted to determine the occurrence of parasitic infection in *C. gariepinus* from Upper River Benue Valley Area, Yola, Adamawa State, Nigeria, using 50 randomly selected *C. gariepinus* from both Lake Geriyo (25 fish) and fish farm (25 fish) in the region. The study was conducted between April and June, 2021. The fish were purchased live from Lake Geriyo and the selected fish farm and their sexes were determined before being examined for parasitic infections. Skin scrapings were obtained and examined for ectoparasites while the gills and the gastrointestinal tracts were dissected and examined for endoparasites. Parasites were isolated and identified using standard parasitological procedures. Five classes of parasites were identified, namely, Nematode, Trematoda, Protozoa, Cestoda and Hirudinea. The prevalence of parasites in *C. gariepinus* sampled from Lake Geriyo indicated that 50.00% male *C. gariepinus*, were infected while female *C. gariepinus* prevalence was 42.86%. In the selected fish farm, the study showed that the prevalence of parasites in male *C. gariepinus* is 85.71%, while female *Clarias gariepinus* were infected with a prevalence of 72.72%. This study revealed that sampled male *C. gariepinus* were more parasitized than female, and the *C. gariepinus* from the fish farm were more infected with parasites than those from the lake.

Keywords: Parasites, *Clarias gariepinus*, Lake Gariyo, Fish farm, River Benue

Introduction

Fish accounts for more than 40% of the protein diet of two-thirds of the global population (Akinsanya *et al.*, 2018). The *C. gariepinus* belonging to the family *claridae* is the most popular fish food which is considered to be one of the most important tropical fish for aquaculture in Nigeria. It is very common in swamps, lakes and rivers throughout Africa and it is one of the main fisherman catches (Eyo *et al.*, 2014). *C. gariepinus* is well appreciated, highly priced and requested for by both fish farmers and consumers in Nigeria in either fresh, smoked or other processed form.

Like humans and other animals, fishes suffer from various disease and parasitic infections (Hoffman, 2015). Parasitic infections of fish are very common all over the world and are of particular importance in the tropics (Bichi and Dawaki, 2010; Ajala and Fawale, 2014). Various parasites are associated with *C. gariepinus* in both the wild and cultured environment where they cause morbidity, mortality and economic losses in aquaculture practice in various parts of the world (Emere, 2014; Biu *et al.*, 2014).

There is an increasing awareness of the importance of parasitic infection as one of the major detrimental factors in fish farming (Ayanda, 2017). However, from Yola, there is a paucity of information on the parasitic status of *C. gariepinus*. Therefore, this study sought to examine the occurrence of parasitic infections in *C. gariepinus* from the Upper River Benue Valley Area of Yola, Adamawa State with the view of quantifying the burden and to evaluate the relationship between infection and the sex of *C. gariepinus*. This area houses the main water bodies and small-scaled fish farms in Adamawa State. 9°20'N 12°30'E / 9°33'N 12°50'E

Materials and Methods

Study Area

The Upper River Benue valley area of Adamawa State (Figure 1) is located between latitude 09° 09' 00" N and 09° 33' 00" N of the equator and between longitude 12° 21' 00" E and 12° 54' 00" E of the prime (Greenwich) meridian. Adamawa state has two marked seasons: the wet season, between April and October and the dry season between November and March (Adebayo *et al.*, 2012). The average maximum and minimum temperatures range between 40° and 26° respectively with a total annual rainfall of about 600 – 1600mm (Mallum, 2016).

Sample collection and preparation

A total number of fifty (50) *C. gariepinus* were sampled for parasitic investigation. Out of these, twenty-five (25) sampled were from Lake Geriyo and twenty-five (25) *C. gariepinus* were from fish farm respectively. The fish samples were transported alive to the Laboratory of Department of Fisheries, Modibbo Adama University, Yola, in two different plastic containers filled with water from collection site for parasitic examination. The sample collection was done from April to June 2021. Sexes of fish were identified by physical observation of the urogenital papillae as described by Lagrue *et al.* (2011).

Identification of Parasites

The external surfaces (skin and fins) were placed under a light microscope for examination. Gills were cut out and placed into separate petri dishes and observed with hand lens for parasites. Parasites were collected and fixed in buffered 5% formalin for further identification (Paperna, 1996). The external examination of the fish surface was first carried out by using hand lens for the detection of parasitic manifestation as described by Tachia *et al.* (2010). Subsequently, a sterile scalpel blade was used to scrape the skin from the head to the tail to obtain skin smear and kept in different sample plates containing 0.9% saline solution. (Adeyemo and Falaye 2007; Ekanem *et al.*, 2014). Drops of the mixed solution were collected using a dropper, placed on a clean slide, and examined. Detection of parasites from the gills of the sampled fish was made by using the methods described by Adeyemo and Falaye (2007), and Ekanem *et al.* (2014).

A cut was making on the ventral side of the fish from the anal opening to the lower jaw using a dissecting scissors to expose the body cavity and most of the internal organs. The stomach and intestine were separated and keep in different sample plates containing 0.9% saline solution. The contents of the stomach and intestine were washing in this normal saline solution for sedimentation and floatation. A drop of the residue was placed on the slide and the wet mount was examined for parasites under the microscope. The parasites were identified using a standard text by Ajala and Fawole (2014) and Kawe *et al.* (2016).

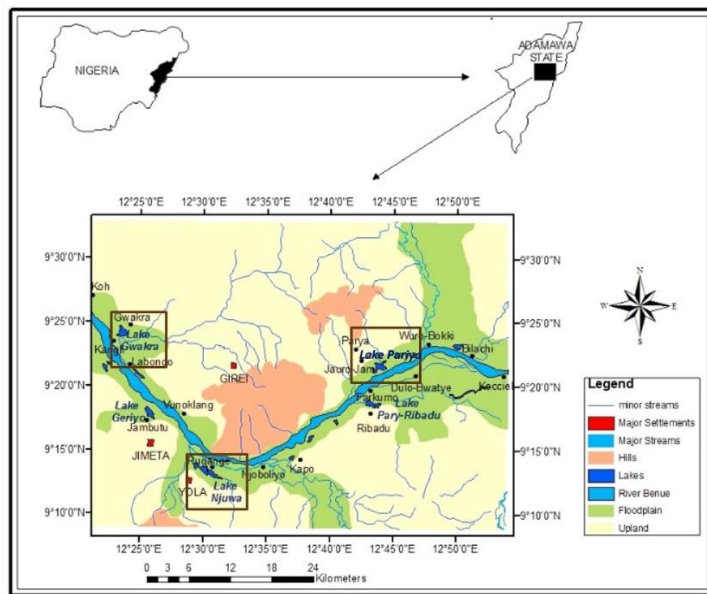


Figure 1. Study area and lakes (Yonnana *et al.*, 2015)

$$\text{Prevalence of Parasite Infection and Intensity (\%)} = \frac{\text{No of fish infected} \times 100}{\text{Total No of fish host examined}}$$

$$\text{Prevalence Based on Sex (\%)} = \frac{\text{No of particular sex of fish host infected} \times 100}{\text{Total No of particular sex of fish}}$$

$$\text{Prevalence Based on Collection Site (\%)} = \frac{\text{No of fish host infected in a collection site} \times 100}{\text{Total No of fish host infected}}$$

$$\text{Intensity of Parasite} = \frac{\text{Total No of parasite species in a sample of fish examined}}{\text{No of fish host infected}}$$

Statistical Analysis

The prevalence and intensity of the infection was calculated using simple percentage (%) sex, parasites-based site, sex, and frequency in relation to prevalence within the samples were analyzed.

RESULTS AND DISCUSSION

The parasites reported were of five classes and species were reported from the study from the gills, skin, stomach and intestine of the *C. gariepinus* sampled respectively. The incidence of parasites in *C. gariepinus* from Lake Geriyo Indicated that the highest number of parasites recovered was found in stomach with total number 6 (50%) follow by 5 (41.66%) in the intestine, and the least parasite was recovered the gill is 1 (8.33%) (Table 1). As showed in Table 2, the incidence of parasites in *C. gariepinus* from fish farm indicated the highest number of parasites recovered in the gill with 8 (36.38%) follow by skin with 6 (27.28%), in the stomach 5 (22.74%) and intestine 3 (13.65%).

Prevalence and intensity of parasites in relation to sex from Lake Geriyo recorded 50.00% in the male *C. gariepinus*, while female *C. gariepinus* were infected with the prevalence of 42.86% (Table 3). Prevalence and intensity of parasites in relation to sex from fish farm as shown in Table 4, 85.71% in the male *C. gariepinus*, while female *C. gariepinus* were infected with the prevalence of 72.72%. The total parasite burden of 12 was recorded in *C. gariepinus* from Lake Geriyo. Among the classes of parasites recovered, it was recorded that the highest burden of parasites was discovered in the Trematoda (33.33%), while the lowest was recorded in Protozoa (16.67%) (Table 5). The total burden of the parasites of 20 was recorded in *C. gariepinus* from cultured fish farm, among the class of parasites recovered, it was recorded that the highest burden of parasites was discovered in Protozoa (35.00%), while the lowest was recorded in Hirudinea (10.00%) (Table 6).

The incidence rate of parasites in *C. gariepinus* examined in this research work revealed a higher number of parasites to found in *C. gariepinus* from the studied fish farm. This could attribute to the fact that *C. gariepinus* in fish farm are more confined together that the ones in the Lake Geriyo. Other factors including poor management practices like poor water quality management, improper nutrition, improper farm sanitation and poor farm husbandry management may also be responsible for the high rate of parasite incidence recorded in the studied fish farm (Idowu *et al.*, 2017).

This observation is in consonance with Obano *et al.* (2010) who noted that infection rates vary greatly from the fish farms to wild, and inferred that this may be associated with the fact that a number of factors like availability of intermediate host, and susceptibility of definite hosts among others determine to a large extent the rate of infection in fish. From this study, sampled male *C.gariepinus* both from Lake Geriyo and the studied fish farm were more parasitized than female. Male fish had higher incidence rate and prevalence rate than female. Emere and Egbe (2016) reported that due to the physiological state of the male, most gravid male could have reduced resistance to infection by parasites. A similar finding was recorded earlier by Emere (2000) who reported differences in the incidence of infestation between male and female *C. gariepinus*, which may be due to differential feeding either by quantity or quality of feed, or as a result of different degree of resistance to infection. The result obtained in this study revealed varying degree of prevalence and intensity rate of parasitic infection in the *C. gariepinus*.

Several researchers have argued that due to sexual selection male are more heavily affected with parasites than female (Omeji *et al.*, 2013). It was further explained that due to competition for mates, male may operate closer to their physiological limit than females hence resulting in higher level of stress and reduced immune competence in male relative to female (Herbert and Cohen, 1993). Authors including; Esiest (2013) and Dan-kishiya *et al.* (2013) also explained that sex biased parasitism in fish can result from differences in immune competence with males predicted to bear a greater cost of sexual selection and immune suppressive effects of testosterone production and thus become more susceptible to parasitic infection than females.

The burden of parasites in *C. gariepinus* from Lake Geriyo corresponded with the number of classes of parasites and also in total parasites number when related to Solomon *et al.* (2016) and explained that carnivorous fish species harbor more heterogeneous communities of parasite than herbivorous species. The result of the classes of parasites recovered from Lake Geriyo and the studied fish farm is consonance with earlier reported work of Sogbesan *et al.* (2018) who report high parasites occurrence in Nematodes, Trematode and Protozoa.

CONCLUSION

This study revealed that sampled male were more parasitized than female. And also cultured fish farm was more infected than wild.

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Table 1 Incidence of parasites in *Clarias gariepinus* from Lake Geriyo

Parasite	No of fish infected	%	Gills	%	Skin		Stomach	%	Intestine	%
<i>Caenorhabditis elegans</i>	2	16.67							2	16.67
<i>Otodistomum spp</i>	2	16.67					2	16.67		
<i>Ichthyophthnous lioteri</i>	1	8.33	1	8.33						
<i>Spirometra reinacei</i>	2	16.67					2	16.67		
<i>Linostomum cumplanatum</i>	1	8.33					1	8.33		
<i>Nesoleathins africans</i>	1	8.33							1	8.33
<i>Protopalina symphysolonis</i>	1	8.33							1	8.33
<i>Pocamallanus spp</i>	1	8.33					1	8.33		
<i>Onobothriode woodlands</i>	1	8.33							1	8.33
Total	12		1				6		5	

Table showing Incidence of parasites in *Clarias gariepinus* from Fish Farm

Parasite	No of fish infected	%	Gills	%	Skin	%	Stomach	%	Intestine	%
<i>Dactylogyrus spp</i>	2	16.67	1	4.55	1	4.55				
<i>Camallanus spp</i>	2	16.67							1	4.55
<i>Philometroides african</i>	1	5.00					1	4.55		
<i>Monobothroide africans</i>	2	10.0					2	9.09		
<i>Piscicola germetid</i>	2	8.33	2	9.09	1	4.55				4.55
<i>Protopalina symphysolonis</i>	1	5.00							1	

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<i>Epistylis spp</i>	1	5.00	1	4.55	2	9.09		
<i>Gyrodactylus spp</i>	1	5.00	1	4.55	2	9.09		
<i>Ichthyophthnous lioteri</i>	2	10.00	2	9.09				
<i>Lytocester marcuseni</i>	1	5.00				1	4.55	
<i>Genohabditis elegans</i>	1	5.00				1	4.55	4.55
<i>Clinostomum complanatum</i>	1	5.00					1	4.55
<i>Ichthyophilus multifiliis</i>	1	5.00	1	4.55				
Total	20		8		6		5	3

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Table 3: Prevalence and intensity of parasite in relation to sex in Lake Geriyo

Sex	No. of Fish Examined	No. of Fish infected	No. of fish recovered	Percentage (%)	Intensity of Parasite
Male	18	9	9	50.00	1.00
Female	7	3	3	42.86	1.00
Total	25	12	12	48.00	

Table 4: Prevalence and intensity of parasite in relation to sex in Cultured Fish Farm

Sex	No. of Fish Examined	No. of Fish infected	No. of fish recovered	Percentage (%)	Intensity of Parasite
Male	14	12	14	85.71	1.17
Female	11	8	8	72.72	1.00
Total	25	20	22	80.00	

Table 5: Burden of parasite in *Clarias gariepinus* from Lake Geriyo

Class of parasites Species	No. of fish infected	Percentage (%)
Nematoda	3	25.00
<i>Caenorhabditis elegans</i>		
<i>Procamallanus</i> spp		
Trematoda	4	33.33
<i>Nesolecithus africanus</i>		
<i>Otodistomum</i> spp		
<i>Clinostomum complanatum</i>		
Protozoa	2	16.67
<i>protoopalina symphysodanis</i>		
<i>Ichthyopthnous hoferi</i>		
Cestoda	3	25.00
<i>Monobothriodes woodland</i>		
<i>Spirometra reinacei</i>		
Total	12	

Table 6: Burden of parasite in *Clarias gariepinus* from a Cultured Fish Farm

Class of parasites Species	No. of fish infected	Percentage (%)
Nematoda	3	15.00
<i>Caenorhabditis elegans</i>		
<i>Camallanus</i>		
<i>Philometroides africanus</i>		
Trematoda	5	25.00
<i>Clinostomum complanatum</i>		
<i>Dactylogyrus</i> spp		
<i>Gyrodactylus</i> spp		
Protozoa	7	35.00
<i>Ichthyopthnous hoferi</i>		
<i>Ichthyopphithius multifilis</i>		
<i>Protoopalina symphysodanis</i>		
<i>Epistylis</i> spp		
Cestoda	3	15.00
<i>Lytocester marcuseni</i>		
<i>Monobothriodes woodland</i>		
Hirudinea	2	10.00
<i>Piscicola geometra</i>		
Total	20	

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EVALUATION OF THE PHYSICOCHEMICAL AND BACTERIOLOGICAL PROFILE OF SOME FISH PONDS FROM A REPUTABLE FARM IN MAKURDI, BENUE STATE, NIGERIA

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ABSTRACT

Evaluation of the physicochemical and bacteriological profile of some selected ponds from a reputable fish farm in Makurdi, Benue State with the aim to ascertain the microbiological and water quality profile of the fish farm was carried out. Water samples were aseptically collected from four earthen ponds biweekly using sterile screw capped bottles according to the methods described by Njoku *et al.* (2015) and Torimiro *et al.* (2014). Composites samples were obtained by collecting at different sampling points and depths of 30cm below the water surface. The water samples were transported to the Fisheries and Aquaculture Laboratory, Joseph SarwuanTarka University, Makurdi in an ice-packed container for physiochemical analysis while the water samples for microbial analysis were taken to the Department of Biological Science, same university in ice-packs and analyzed between 2-3 hours after collection. Variations in mean physicochemical parameters existed among the ponds. pH, ammonia, nitrite, and dissolved oxygen were highest in concrete pond B and temperature, electric conductivity and BOD were highest in concrete pond A. Alkalinity was highest in earthen pond B. The mean averages of the Total Viable Count(TVC) (cfu/ml), Total Coliform Count(TCC) and Total Fungal Count(TFC) of bacteria from the concrete ponds were 13.65×10^5 , 66.53×10^5 and 4.65×10^5 while the mean averages of the TVC (cfu/ml), TCC and TFC of bacteria from the earthen ponds were 12.65×10^5 , 86.53×10^5 and 4.25×10^5 , respectively. While higher mean averages of the TVC (86.53×10^5) and TFC (4.25×10^5) were recorded for concrete ponds, earthen ponds recorded 12.65×10^5 and $.25 \times 10^5$. On the other hand, while higher mean averages of TCC (86.55×10^5) was recorded for earthen ponds, concrete ponds recorded mean averages TCC of 66.53×10^5 . A total of nine (9) bacteria isolates were encountered from both the earthen and concrete ponds during the study period. Of the nine (9) bacteria isolates, while *E. coli* had the highest percentage frequency of occurrence (25.00%), the least (1.92%) was recorded for *Pseudomonas sp.* Four (4) fungi isolates comprising of *Aspergillus sp*, *Pennnicillum sp*, *Rhizopus sp* and *Mucor sp* were observed from both the earthen and concrete ponds. Of the total percentage frequency, while *Aspergillus sp* had the highest percentage frequency (50.00%), the least (4.35%) was recorded for *Rhizopus sp*.

Keywords: Physico chemical Profile, microbiological profile, concrete ponds, earthen ponds, Makurdi

INTRODUCTION

Water is the most important resource for aquaculture and can be a significant source for contamination. The conditions that fishes are cultured may be potentially stressful, causing existing infections to become more severe and precipitate disease outbreaks which may also compromise the fitness of such fish for human consumption. According to Ugwuba and Chukwuji (2010), the mortality of fish due to disease and water pollution constitutes problems to aquaculture development in Nigeria.

Most of the world's population (56 percent) derives at least 20 percent of its animal protein intake from fish (FAO, 2002). Fish is the preferred source of much desired animal protein compared to poultry, beef, mutton or pork. It is comparatively cheaper and highly acceptable with little or no religious bias which gives it advantage over other proteins (Philips, 2004). Fishes are reared in different culture media or controlled

environment which could be ponds (concrete or earthen), vats (wooden or fiber glass) and plastics (Osawe, 2004). Among these culture systems, concrete and earthen ponds are widely used (Ezenwa, 2006).

As a result of high cost of feeding, animal manure has been one alternative that has been used to supplement or completely replace conventional feed in country like China, India, and also in Nigeria. However, organic manuring also leads to the release of high concentration of opportunistic and pathogenic microorganisms into the ponds which are of public health concerns. Their presence in fish intended for human consumption may constitute a potential danger not only in causing disease (Omojowo and Omojosola, 2013). In view of this, this study aimed to ascertain the microbiological and water quality profile of the fish farm under study.

Materials and Methods

Sample Collection

Water samples were aseptically collected from four earthen ponds biweekly using sterile screw capped bottles according to the methods described by Njoku *et al.* (2015) and Torimiro *et al.* (2014). Composites samples were obtained by collecting at different sampling points and depths of 30cm below the water surface. The water samples were transported to the Fisheries and Aquaculture Laboratory, Joseph SarwuanTarka University, Makurdi in an ice-packed container for physicochemical analysis while the water samples for microbial analysis were taken to the Department of Biological Science, Joseph SarwuanTarka University, Mkaurdi in ice-packs and analyzed between 2-3 hours after collection.

Physicochemical analysis of water sample

The water samples from the different ponds of the reputable farm were examined for physicochemical characteristics using standard procedures of the American Public Health Association (APHA 2000).

4 plastic bottles of 150Cl, one each for every sampled fish pond were properly washed and rinsed and labeled as A1 (concrete pond 1), A2 (concrete pond 2) and B1 (earthen pond 1), B2 (earthen pond 2) respectively. Water samples were collected in each bottle by dipping the bottle 30cm below the water level at designated sampling stations and brought to the laboratory for the determination of Carbon dioxide, Alkalinity and Hardness titrimatically. Transparency was determined with the aid of a standard Secchi disc. Reagent bottles of 250ml were used to collect water samples from each pond and incubated for five (5) days in an enclosed chamber for BOD determination. Physicochemical parameters such as Temperature, Total Dissolved Solids (TDS), Hydrogen Ions Concentration (pH), Electrical Conductivity (EC) and Dissolved Oxygen (DO) were all measured in situ using Hanna portable (pH/EC/TDS/temperature waterproof test kit, model: HI 98129). The DO was measured using DO meter while air temperature was measured using the mercury in glass thermometer.

Microbial Analysis

The microbial load of the water from the fish ponds was determined by performing a ten-fold serial dilution of the sample in test tubes containing sterile distilled water. The Total Viable bacterial Count was determined using the pour plate technique cultured in duplicates. The plates were incubated at 35°C for 48 hours. The colonies were counted and expressed in colony forming unit per ml (cfu/ml) and values were estimated by means of duplicate determination. The isolated colonies were streaked on nutrient agar and pure cultures of the bacterial isolates were subjected to various morphological and biochemical characterization tests (Cheesbrough, 2006) to determine the identity of the bacteria isolates with reference to Bergey's Manual of Determinative Bacteriology (Buchanan and Gibbons, 1974).

RESULTS AND DISCUSSION

Table 1 shows the mean physicochemical parameters of water samples from the concrete and earthen ponds of the farm while Table 2 shows the Total Viable Count, Fungal Count, and Coliform Count of the water samples from concrete and earthen ponds of the farm. In Table 1, variations in mean physicochemical parameters existed among the ponds. pH, ammonia, nitrite, and dissolved oxygen were highest in concrete

pond B; temperature, electrical conductivity and BOD were highest in concrete pond A. Alkalinity was highest in earthen pond B.

In Table 2, the mean averages of the Total Viable Count (cfu/ml), Total Coliform Count and Total Fungal Count from the concrete ponds were 13.65×10^5 , 66.53×10^5 and 4.65×10^5 while the mean averages of the Total Viable Count (cfu/ml), Total Coliform Count and Total Fungal Count from the earthen ponds were 12.65×10^5 , 86.53×10^5 and 4.25×10^5 , respectively. While higher mean averages of the TVC (86.53×10^5) and TFC (4.25×10^5) were recorded for concrete ponds, earthen ponds recorded 12.65×10^5 and $.25 \times 10^5$. On the other hand, while higher mean averages of TCC (86.55×10^5) was recorded for earthen ponds, concrete ponds recorded mean averages TCC of 66.53×10^5 .

In Table 2, A total of nine (9) bacteria isolates were encountered from both the earthen and concrete ponds during the study period. Of the nine (9) bacteria isolates, while *Escherichia coli* had the highest percentage frequency of occurrence (25.00%), the least (1.92%) was recorded for *Pseudomonas sp*.

Table 1: Mean physicochemical parameters of water samples from the concrete and earthen ponds

Water parameters	Pond types			
	Concrete pond A	Concrete pond B	Earthen pond A	Earthen pond B
pH	5.22±0.19 ^a	5.48±0.03 ^a	5.47±0.01 ^a	5.45±0.05 ^a
Temperature	26.62±0.01 ^c	26.57±0.04 ^{bc}	26.50±0.01 ^b	26.35±0.05 ^a
Turbidity	10.59±0.01 ^c	0.42±0.06 ^b	0.31±0.01 ^a	0.25±0.05 ^a
Ammonia	0.10±0.00 ^a	0.21±0.01 ^b	0.10±0.00 ^a	0.13±0.03 ^a
Nitrite	3.56±0.25 ^b	4.25±0.25 ^b	1.25±0.05 ^a	0.95±0.05 ^a
EC	28.82±0.03 ^a	22.00±0.20 ^b	22.55±3.95 ^a	25.25±0.25 ^a
Alkalinity	1.51±0.50 ^d	1.00±0.25 ^c	18.20±0.10 ^a	24.35±0.25 ^b
DO	9.90±0.10 ^b	10.55±0.05 ^c	8.15±0.15 ^a	10.10±0.10 ^b
BOD	5.50±0.30 ^b	5.25±0.05 ^{ab}	4.86±0.06 ^a	4.95±0.05 ^{ab}

EC = Electric conductivity, DO = Dissolved oxygen, BOD = Biological oxygen demand

Table 2: Total Viable Count, Fungal count, and Coliform count of the water samples from concrete and earthen ponds

Source of water	Counts		
	TVC(cfu/ml)	TCC(cfu/100ml)	TFC(cfu/ml)
Concrete Pond A	6.20 x 105a	51.28 ^b	2.10 x 105a
Concrete Pond B	7.45 x 105a	15.25 ^a	2.55 x 105b
Total	13.65 x 105a	66.53 x 105a	4.65 x 105a
Earthen Pond A	6.50 x 105a	21.25 ^a	1.85 x 105a
Earthen Pond B	6.15 x 105a	65.30 ^c	2.40 x 105b
Total	12.65 x 105a	86.55 x 105a	4.25 x 105a

Table 3 shows the distribution and number/percentage frequency of occurrence of bacteria isolates from the concrete and earthen ponds of this reputable farm while Table 4 shows the distribution and number/percentage frequency of occurrence of fungi isolates from the concrete and earthen ponds of the farm. In Table 3, a total of nine (9) bacteria isolates were encountered from both the earthen and concrete ponds during the study period. Of the nine (9) bacteria isolates, while *E. coli* had the highest percentage frequency of occurrence (25.00%), the least (1.92%) was recorded for *Pseudomonas sp*. In Table 4, a total of four (4) fungi isolates comprising of *Aspergillus sp*, *Pennnicillum sp*, *Rhizopus sp* and *Mucor sp* were observed from both the earthen and concrete ponds. Of the total percentage frequency, while *Aspergillus sp* had the highest percentage frequency (50.00%), the least (4.35%) was recorded for *Rhizopus sp*.

Table 3: Distribution and number/percentage frequency of occurrence of bacteria isolates from the concrete and earthen ponds

Isolates	Concrete Pond A	Concrete pond B	Earthen pond A	Earthen pond B	No./%Frequency
<i>Aeromonas sp</i>	+	+	+	+	29(18.59)
<i>Staphylococcus sp</i>	+	+	+	+	25(16.03)
<i>Salmonella sp</i>	+	+	+	+	7(4.49)
<i>Enterobacter sp</i>	+	+	—	+	3(1.92)
<i>Shigella sp</i>	+	+	+	+	17(10.90)
<i>Escherichia coli</i>	+	+	+	+	39(25.00)
<i>Pseudomonas sp</i>	+	+	+	+	3(1.92)
<i>Klebsiella sp</i>	+	+	+	+	19(12.18)
<i>Proteus sp</i>	+	+	+	+	5(3.21)
<i>Streptococcus sp</i>	+	+	+	—	9(5.77)

Table 4: Distribution and number/percentage frequency of occurrence of fungi isolates from the concrete and earthen ponds

Ponds	<i>Aspergillus sp</i>	<i>Penicillium sp</i>	<i>Rhizopus sp</i>	<i>Mucor</i>
Concrete pond A	+	+		—
Concrete pond B	+	+	—	—
Earthen pond A	+	+		+
Earthen pond B	+	+		+
% frequency	23(50.00)	18(39.13)	2(4.35)	3(6.52)

Physicochemical and microbiological profiles of selected fish ponds from a reputable fish farm in makurdi, Benue state, Nigeria were evaluated. According to Torimiro *et al.*, (2014), physicochemical parameters such as alkalinity, dissolved oxygen, total hardness, pH and temperature are the most common water quality characteristics that will influence fish health and growth. The finding from the physicochemical analysis revealed values that are within the range approved for warm water fish.

The results of the bacteriological characteristics in this study showed that the gram negative bacteria dominated in the bacteria isolated from the ponds. The microorganisms isolated were *Aeromonas sp*, *Staphylococcus sp*, *Salmonella sp*, *Enterobacter sp*, *Shigella sp*, *E. coli*, *Pseudomonas sp*, *Klebsiella sp*, *Proteus sp*, and *Streptococcus sp*. Isolation of these organisms from the studied farm is not surprising as they have been previously discovered from other fish ponds. The discovery of the organisms in the present study is in agreement with the reported work of Torimiro *et al.* (2014). The coliforms isolated were indication of the contamination of the pond water with fecal material which may be as a result of fertilization of the ponds with animal manure which is discharged directly into the fish ponds, or excreted by the fish into the ponds or through runoff (Kay *et al.*, 2008). The diverse groups of bacteria isolated from these ponds are in line with the report of Okpokwasili and Ogbulie (1999) who worked on pond water suggesting that allochthonous bacteria from feed added to the ponds are the principal source of bacteria of health importance and Dabbor (2008) who reported similar organisms in the microbiological study of el-quanter fish pond. The presence of pathogenic microorganisms especially *E. coli*, *Salmonella*, and *Shigella* can lead to the transmission of water borne diseases such as; Typhoid fever, cholera, food poisoning and gastroenteritis (Piet 2009) on consumption of improperly cooked fish cultivated in these ponds. *E. coli* was the most dominant organism occurring in both concrete and earthen ponds. The presence of *E. coli* in water or food indicates the possible presence of causative agents of many gastrointestinal diseases (Ampofo and Clerk, 2010). *Pseudomonas*, *proteus*, *Staphylococcus species* have been implicated in food poisoning (Oni *et al.*, 2013). *Aeromonas* species were also predominantly present in both ponds. This organism is one of the most

opportunistic pathogen for fresh water fish and the main etiological agent in disease outbreak where several mortalities were recorded (Das and Mukheyce, 1999).

CONCLUSION

The physicochemical analysis revealed values that are within the range approved for warm water fish. The result of the bacteriological characteristics in this study is of public concern as it showed that the gram negative bacteria dominated in the bacteria isolated from the ponds. The microorganisms isolated were *Aeromonas sp*, *Staphylococcus sp*, *Salmonella sp*, *Enterobacter sp*, *Shigella*, *E. coli*, *Pseudomonas*, *Klebsiella sp*, *Proteus sp* and *Streptococcus sp*.

RECOMMENDATION

Further studies on the microbiological and water quality profile of both this and other fish farms should be carried out subsequently so as to combat microbial loads and proper management of the water for aquatic lives.

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ANTIBIOTIC RESISTANCE OF *AEROMONAS HYDROPHILA* ISOLATED FROM WILD AND CULTURED *CLARIAS GARIEPINUS* IN ASABA, DELTA STATE.

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ABSTRACT

The continual raise in bacteria resistance to therapeutic antibiotics is a global health challenge. This study was carried out to determine the susceptibility and antibiotic resistance of *Aeromonas hydrophila* isolated from wild and cultured *Clarias gariepinus*. The isolation of *A. hydrophila* was carried out using standard methods and subjected to antibiotic susceptibility test using seven different antibiotics (AMP = Ampicillin (10µg), STR = Streptomycin (15µg), TET = Tetracycline (30µg), CIP = Ciprofloxacin (5µg), Azi = Azithromycin (10µg), TRS = Trimethoprim/sulfamethoxazole (10µg) and CHL = Chloramphenicol (10 µg)). A total of 15.63%, 46.88 % and 37.5% were isolated from the skin, intestine and gill respectively from the wild fish while 11.11%, 50% and 38.89 % were isolated from the skin, intestine and gill respectively from the cultured fish. The Multiple Antibiotic Resistance test (MAR) showed that all isolates had multiple antibiotic resistance indices >0.2. Both the wild and cultured fish demonstrated a low resistance to chloramphenicol (6.25% in wild and 5.56% in cultured) but isolates from the cultured source were more resistant to the β -lactam drug (ampicillin) with a value 94.44% when compared to the wild source (87.5%).

Keywords: *Aeromonas hydrophila*, antibiotic susceptibility, antibiotic resistance, fish.

INTRODUCTION

The well-being of a fish and its aquatic environment; can be examined by biochemical and microbial assays. The bacterial flora detected in any fish illustrates not only the healthiness of the fish but of its environment. The maximum microbiological limit for bacterial count in flesh and guts of fish are 10^7 colony forming units per gram (cfu/g) and 10^9 colony forming units per gram (cfu/g) respectively (Mahendra *et al.*, 2016). An elevation in microbial colony forming units per gram in a contaminated water body exposes an inhabiting aquatic organism to pathogens (Kostadinov *et al.*, 2018).

The source of bacterial infection from microorganisms in fishes may possibly be as a result of runoff in their aquatic environment, generation of municipal waste, poor sanitation, fertilizer and pesticides application (Moses *et al.*, 2019). There are often times an outbreak of a disease in cultured fish and in most, the antibiotics used for the treatment of the infectious diseases in fish remains as residues in the flesh and gills of the fish(s) treated (Njoku *et al.*, 2015). These residues that remain are unsafe because they maybe ingested by the fish predators and even humans. Aside the overuse of antibiotic drugs, microorganisms from fecal waste could contain antibiotic resistant gene that may circulate and contaminate the aquatic environment (Larsson, 2014). The exposure of bacteria to environmental alterations and even antibiotics if not properly administered could lead to the development of bacteria resistance genes that could be transferred in the aquatic environment via direct contact with fish, or indirectly from the food chain (Salinas *et al.*, 2019).

Aeromonas hydrophila is a heterotrophic gram negative rod shaped bacterium. In Nigeria, *A. hydrophila* is one of the most predominate biotic factors bacteria pathogen found in freshwater fishes (Adesiyun *et al.*, 2019; Alegbeleye *et al.*, 2019 and Owolabi *et al.*, 2019). It is responsible for infection such as tail rot, fin rot and hemorrhagic septicemia in both captured and wild fish. Hemorrhagic septicemia causes lesions that lead to scale shedding, hemorrhages in the gills and anal area, ulcers, exophthalmia, and abdominal swelling (Tan *et al.*, 2015). A greater risk of infection is reported in young children, elderly people, and immune-compromised patients (Janda, 1991). These bacterial floras are found in gills, outer slime and intestines of the fish (Ibrahim, *et al.*, 2016 and Njoku *et al.*, 2015).

Structurally, *Aeromonas hydrophila* comprises of a thin peptidoglycan layer and two membranes (inner and outer). These peptidoglycans are made up of N-acetyl muramic acid (NAM) and N-acetyl glucosamine (NAG) cross-linked by chains of amino acid (Romero *et al.*, 2015). Its cell wall plays a role in its susceptibility to and resistance of, antibiotic drugs. Like other gram negative bacteria, a pink color is formed upon gram staining. The mechanism of action for the susceptibility of anti-microbial drugs has been documented (Holmes *et al.*, 2019; Gustine *et al.*, 2019; Venter *et al.*, 2015). This can be by inhibiting cell wall biosynthesis, protein biosynthesis, DNA replication/repair and folate coenzyme biosynthesis (Holmes *et al.*, 2019; Gustine *et al.*, 2019; Venter *et al.*, 2015). The major classes of antibiotics are the cell wall biosynthesis inhibitors such as penicillin. Tetracycline and Aminoglycosides are examples of protein inhibitors. Quinolones are examples of DNA and RNA biosynthesis inhibitors that attack DNA gyrase or topoisomerases and inhibition of DNA/RNA precursor synthesis such as sulphafurazole that block two different steps in the biochemistry of folic acid coenzyme.

The acquisition of resistance gene by bacteria is by two ways; the vertical gene transfer and the horizontal gene transfer. The vertical gene transfer is rare and it entails a spontaneous mutation. The horizontal gene transfer is transferred through three different ways; conjugation (via plasmids), transduction (via bacteriophages) and transformation (via transposons) (Alekhshun and Levy, 2007). Hence, antibiotic resistance in most cases is present in the bacteria plasmid and may be intrinsic although at times acquired (Barbosa and Levy, 2000). In β -lactam antibiotics resistance, the antibiotic resistance gene is translated into β -lactam dehydrogenase (an antibiotic degrading enzyme) which breakdown the β -lactam ring in an antibiotic drug thereby rendering it inactive. Aside translating genes into antibiotic degrading enzymes, they may also produce an efflux pump as an intrinsic mechanism. Hence pumping out the antibiotics or modifying the antibiotics binding proteins. Efflux pump systems are now recognized as the major contributors to multiple resistances in bacteria (Alekhshun and Levy, 2007). Hence, this study was undertaken to determine the level of antibiotic resistance of *Aeromonas hydrophila* isolated from *Clarias gariepinus*.

Materials and method

Sample Collection

A total number of ten *Clarias gariepinus* were randomly caught from the wild (River Niger) in Asaba, Delta State, Nigeria. Ten *Clarias gariepinus* which manifested tail rot and fin rot were sourced from various fish farms in Asaba, Delta State.

Dissecting to remove the gills and intestine

After being aseptically thawed for 2-4h at ambient temperature, the fish surfaces were carefully wiped by cotton with 70% ethanol. The fish samples were dissected using aseptic techniques to remove the gills and intestine then stored for microbial analysis as described by Begum *et al.* (2019).

Bacteriological Analysis

The bacteria commensal flora were isolated from the gills and intestines of the fish samples with the purposes of selecting collections of *Aeromonas hydrophila*. This was achieved by serial dilution method and pour plate method according to Akinyemi and Buoro (2011).

✓ Isolation of *Aeromonas hydrophila*

Aeromonas hydrophila was isolated by spread-plating 0.1 ml of homogenous dilution of 10^{-2} to 10^{-5} concentration on Agar. Typical colonies (about 40-80 colonies/station) with maltose fermentation (yellow to honey-colored colonies) and no hydrogen sulfide (H_2S) (no black center) production, were chosen as described by Sirisha *et al.*, (2017). Appearance of an alkaline surface and acid butt on the bottom of the tube after 24 h at 37°C demonstrated the presence of *Aeromonas* spp. *A. hydrophila* was identified by standard physiological and biochemical tests.

Antibiotic susceptibility test

Antibiotic susceptibility test was performed using cup assay method as described by Sirisha *et al.*, (2017). Overnight culture of the test organism were spread on nutrient agar plates and the plates were incubated at 37 °C for 16h by using sterile borer, on each plate separate cups were made for pouring antibiotics separately. Amongst the various category of antibiotic drugs; Ampicillin 10µg, Streptomycin 15µg, Tetracycline 30µg, Ciprofloxacin 5µg, Azithromycin 10µg, Trimethoprim/sulfamethoxazole 10µg, and Chloramphenicol 10 µg.

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All the plates were incubated at 37°C for 48h. The inhibition zone around each cup were observed against each antibiotic and also against each bacterium. Plates without any antibiotic concentration were treated as reference plates. Level of resistance to an antibiotic were assumed as extremely high if more than 80% of isolates are resistant to that antibiotic and similarly, for high > 40%, moderate 20-40%, low 10-20%, and rare < 10%.

MAR (multiple antibiotic resistances) index calculation

The MAR index were calculated using the formula: MAR index = a/b according to (Gufe *et al.*, 2019)

Where “a” represents the number of antibiotics to which the isolate was resistant and “b” represents the number of antibiotics to which the isolate was exposed.

A MAR index value of ≤ 0.2 were considered to indicate antibiotics are seldom or never used. A MAR index value > 0.2 were indicated high risk source of contamination antibiotics are commonly used.

Results and Discussion

Table 1: Isolation frequency of *Aeromonas hydrophila* from gill, intestines, and skins of fish samples collected

Fish source	Number of sampled fish	The number of fish that tested positive for <i>Aeromonas hydrophila</i> (%)	Fish body part and number of <i>Aeromonas hydrophila</i> isolated from it (%)		
			Gills	Intestine	Skin
Wild	10	6 (60)	12 (37.5)	15 (46.88)	5 (15.63)
Cultured	10	10 (100)	7 (38.89)	9 (50)	2 (11.11)

The frequency of *A. hydrophila* from the various parts of the fish is presented on Table 1. All the 10 fish samples obtained from fish farms had such as wounds to the skin, damaged fins and tail. A total of 32 and 18 isolates of *A. hydrophila* were detected in the wild source and cultured source respectively.

Table 2: Antibiotic resistant test against *Aeromonas Hydrophila* for the wild fish

Antibiotics	Sensitivity (%)	Intermediate (%)	Resistant (%)
AMP (10µg)	3 (9.38)	1 (3.3)	28 (87.5)
STR (15µg)	9 (28.13)	2 (6.25)	21 (65.63)
TET (30µg)	9 (28.13)	4 (12.5)	15 (46.88)
CIP (5µg)	28 (87.5)	-	3 (9.38)
AZI (10µg)	12 (37.5)	5 (15.63)	15 (46.88)
TRS (10µg)	9 (28.13)	3 (9.38)	19 (59.38)
CHL (10 µg)	24 (75)	6 (18.75)	2 (6.25)

Where, AMP = Ampicillin, STR = Streptomycin, TET = Tetracycline, CIP = Ciprofloxacin, Azi = Azithromycin, TRS = Trimethoprim/sulfamethoxazole and CHL = Chloramphenicol.

Table 3: Antibiotic resistant test against *Aeromonas Hydrophila* for the cultured fish

Antibiotics	Sensitivity (%)	Intermediate (%)	Resistant (%)
AMP (10µg)	1 (5.56)	-	17 (94.44)
STR (15µg)	8 (44.44)	-	10 (55.56)
TET (30µg)	9 (50)	7 (38.89)	2 (11.11)
CIP (5µg)	14 (77.78)	2 (11.11)	2 (11.11)
AZI (10µg)	9 (50)	-	8 (44.44)
TRS (10µg)	9 (50)	-	9 (50)
CHL (10 µg)	17 (94.44)	-	1 (5.56)

Where, AMP = Ampicillin, STR = Streptomycin, TET = Tetracycline, CIP = Ciprofloxacin, Azi = Azithromycin, TRS = Trimethoprim/sulfamethoxazole and CHL = Chloramphenicol.

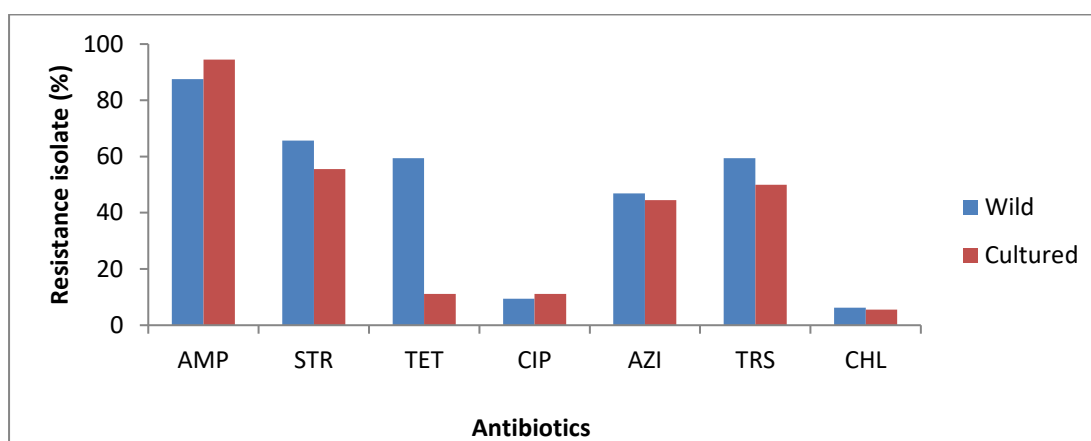


Fig 1: Percentage of *Aeromonas hydrophila* resistant to antibiotics tested

Where, AMP = Ampicillin (10µg), STR = Streptomycin (15µg), TET = Tetracycline (30µg), CIP = Ciprofloxacin (5µg), Azi = Azithromycin (10µg), TRS = Trimethoprim/sulfamethoxazole (10µg) and CHL = Chloramphenicol (10 µg).

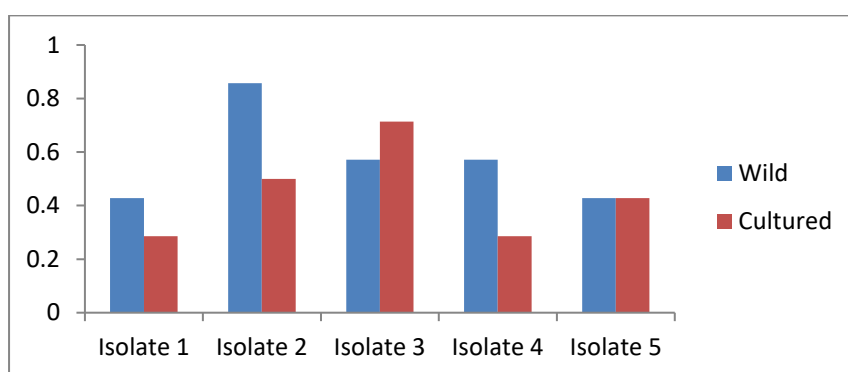


Fig 2: MAR index of *A. Hydrophila* isolates from the fish samples

The wellbeing of an aquatic organism matters a lot when it comes to an exposure to pathogenic bacteria such as *A. hydrophila*. The frequency of *A. hydrophila* isolated from the various parts of the *C. gariepinus* used in this study is given in Table 1. Amongst the isolates detected in the wild fish, 15.63%, 46.88 % and 37.5% were gotten from the skin, intestine and gill respectively. Similarly, 11.11% 50% and 38.89 % were gotten from the skin, intestine and gill respectively from the cultured fish. This finding is similar to the findings of Omeje and Chukwu, (2014) who reported a total of 30.5% prevalence of *A. hydrophila* isolate in selected fish farms within Kainji lake area.

Furthermore, the results of the antibiotic resistance of the *A. hydrophila* isolates extracted from the wild and cultured fish sources are shown on Table 2 and Table 3 respectively. Although isolates from the cultured source were more resistant to the β -lactam drug (ampicillin) with a value 94.44% when compared to the wild source (87.5%) both the wild and cultured fish were resistant to ampicillin, streptomycin and trimethoprim/sulphamethoxazole. The high resistance to β -lactam drug by *A. hydrophila* isolates from the cultured fish source might be as a result of an excessive exposure to antibiotic usage in aquaculture. The result of the antibiotic resistance of *A. hydrophila* in this study agrees to the findings of Ulkhaq and Lusiastitu (2017) who reported that *A. hydrophila* extracted from catfish were resistant to clindamycin (2 µg), penicillin (10 µg) and ampicillin (10 µg). In 2010, Tayler reported that *A. hydrophila* displayed a resistance to β -lactams antibiotic drugs as a result of their ability to express the chromosomal enzyme-lactamase. Actually some bacteria are naturally resistant to certain antibiotics such as anaerobic bacteria to aminoglycosides, or gram negative bacilli to β -lactam antibiotics due to outer membrane permeability barrier (Li *et al.*, 1994;

Barbosa and Levy, 2000; Poole, 2001). Schmieder and Edwards (2012) stipulated that the mode of antibiotic resistance by bacterial to aminoglycosides, β -lactams, macrolides, quinolones and tetracyclines categories were by increase efflux. However, the least resistance was observed on chloramphenicol (6.25% in wild and 5.56% in cultured), Ciprofloxacin (9.38% in wild and 11.11% in cultured) and Tetracycline (11% in cultured). While the highest sensitivity (94.44%) was for chloramphenicol and it was recorded in the isolate from the cultured fish.

The multiple antibiotic resistances index helps in analysing health risk as well as to confirm the extent of antibiotic resistance (Joseph *et al.*, 2017). In this study, all isolates had multiple antibiotic resistance indices >0.2 .

It is highly recommended that antibiotic resistant *A. hydrophila* should be controlled as it was present in both the cultured fish and the wild fish. One of the utmost concern about the wild source is that the stream is a dumpsite for runoff water as a storm control and designed to empty into the River without treatment. These findings can serve as background information for more studies to be done on runoff water emptying into the Anwia stream which happens to flow into the River Niger in Delta State Nigeria.

CONCLUSION

The antibiotic resistance to drugs for bacterial infection is rapidly increasing and this threatens the efficacy of limited aquaculture approved drugs. This study shows the presence of a resistant *Aeromonas hydrophila* in both the wild and cultured *Clarias gariepinus* fish from the two sources in Asaba, Delta State. Isolates from fish samples from both sources had multiple antibiotic resistances index greater than 0.2. For the wild fish, considering the feature of the aquatic body which allows runoff water into it, local markets (Cable and Ogbeogonogo markets) and an abattoir (Anwai axis) not far from it, the result suggests that waste deposited with such municipal waste and poor sanitation can possibly enhanced the presence of *Aeromonas hydrophila* as well as other pathogenic bacteria and their resistance to antibiotics. While the presence of antibiotic resistant bacteria in cultured fish can be as a result of long overuse of antibiotics.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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FISH PRESERVATION, PROCESSING AND VALUE ADDITION

EFFECTS OF MORINGA LEAVES AND GINGER RHIZOME ON PROCESSING, NUTRITIONAL AND SENSORY QUALITIES OF WHOLE AND FILLETED *CLARIAS GARIEPINUS*

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ABSTRACT

This study examined the effects of moringa leaves and ginger rhizome on nutritional and sensory qualities of processed *Clarias gariepinus*. Samples of the fishes were procured from Bagudu farm Jalingo and transported in iced box to Department of Fisheries, Taraba State College of Agriculture, Jalingo. The fish was processed using three different processors which are; Improved Kainji Drum Kiln (IKDK), Improved Adrian Kiln (IAK) and Solar Box Dryer (SBD). Seventy five pieces of *Clarias gariepinus* were used for the experiment. Four each of the differently processed fish samples were evaluated using AOAC (2000) methods while organoleptic test was carried out on the remaining fish samples. The proximate composition of processed *Clarias gariepinus* range from 92.5 – 94.8%, Dry matter, 56.2-64.69%, Crude protein 10.5-16.5%, Crude lipid, 3.5-7.55%, Ash, 5.0-9.6% Crude fat and 1.6-12.9% Nitrogen free extract for IKDK. In IAK, Dry matter was 89.0-94.5%, Crude protein 29.2-56.7% (Crude protein), 16.72-22.1% (Crude lipids), 8.5-10.25% (ASH), 6.75-11.46% (Crude fibre) and 1.14-6.5 (Nitrogen Free Extract) while in SBD, 90.0-96.0% (dry matter), 59.0-66.8% (Crude protein), 8.65-14.4% (Crude lipid), 1.5-9.0% (Ash), and 1.27-7.44 (Nitrogen free extract). The organoleptic test for *Clarias gariepinus* showed preference for fish processed in the Kilns in terms of taste, colour, aroma, appearance and texture. This study therefore, recommends Improved Adrian Kiln processor as the most preferred kiln for fish smoking.

Keywords: *Clarias gariepinus*, Ginger rhizomes, Moringa leaves, Nutritional values, Sensory evaluation

INTRODUCTION

Fish is an important food in countries with long coastlines and extensive inland water resources like Nigeria where fish constitutes about 41% of the total animal protein intake by the average Nigerian, (Oyakhilomen and Zibah, 2013). The demand for fish in Nigeria is still not met, despite having a domestic production estimated at about 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 (Akinsorotan, 2019). Freshwater fish constitute about 69.6% of the total fish supply available to Nigeria, Federal Office of Statistics (FOS, 2016).

Fish has a high nutritional value for humans. It is mainly composed of water ranging from 60 to 80% proteins on dry basis with biological value from 15 to 23% and rich in minerals and such as potassium, phosphorus, iron and vitamins A and C (Sanfilipo *et al.*, 2011). Above all the quantity and the composition of fats which is rich in Omega - 3 makes it differ from other nutritious food items (Watters *et al.*, 2012). The fisheries and aquaculture sector is also a source of employment and income, supporting the livelihoods of 10 – 12 percent of the world's population (Adebayo, 2015). Despite the popularity of fish farming in Nigeria, the industry can best be described as being at the infant stage, when compared to the large market potential for its production and marketing (Adeboye, 2013).

Although consumers are generally attracted by the flavor of smoked fish, its nutritive value is of paramount importance, since every consumer would want to obtain good quality protein from fish consumption, (Omojowo and Ihuni, 2006). Most of the studies on nutritional values of smoked fish centered on lysine and amino-acid which is limiting in cereals and root crops. The loss of lysine is proportional to the temperature and duration of heating. Omojowo and Ihuni (2006) and Agbabiaka *et al.*, (2012) have reported that, smoking causes some decrease in available lysine. The lysine loss is partly attributed to high temperature effects as a result of Millard reaction that involves the amino group amino acids with sugars (usually glucose or ribose) and carbonyl. The latter may be derived from fat or probably from smoke. These changes are necessary to give the characteristics golden brown color of smoked fish. However, over 75% of the protein and more than 50% of vitamins and minerals are still retained in smoked fish (Agbabiaka *et al.*, 2012). The loss of water increases the concentration of nutrients and the denaturation effect of smoking

increases the digestibility of protein and hence the availability of some essential amino acids. The commonest smoking kilns in Nigeria are the “Banda” type which may be constructed with mud, Watanabe smoking kiln, Altona smoking kiln. This study examined the effects of three processors which are Improved Kainji smoking kiln (IKDK), Improved Adrian Kiln (IAK) and Solar Box Dryer (SBD) on the nutritional quality and sensory attributes of *clarias gariepinus* treated with Moringa leaves and Ginger rhizomes.

MATERIALS AND METHODS

Study Area

The study was conducted in Jalingo, Taraba State, Nigeria. Jalingo is situated between longitude 8° 89'N and Latitude 11° 36'E its climatic condition tallies with the two (dry and wet) season commonly experienced in the tropical region. Predominantly, farming and livestock rearing are the major occupation of the people within the study area (Oruonye, 2014).

Experimental Design

The research was conducted with a Complete Randomized Design (CRD) with three Factors via; Factor ‘A’ Processors; Drum, Adrian and Solar. Factor ‘B’ Components; Whole and Fillets. Factor ‘C’ Treatments; *Moringa* and *Ginger*.

Collection and processing of whole and filleted *C. gariepinus*

Seventy-five *Clarias gariepinus* species samples were purchased from Bagudu farms Ltd, Jalingo. The fish sample collected were washed in clean water, eviscerated and dipped in a brine solution (5% sodium chloride) for 10 minutes; then allowed to drain according to Ikeme and Bhandary (2001). The fish species was treated whole and fillets.

Fish Processing and Smoking Procedures

Processing using IKDK, Whole and gutted fish was spread on the racks with the open end facing the fire source to allow for quick dehydration of the fish. The drum is then covered on top and the side door, the temperature of the chamber was 80°C. The drying rate or moisture loss was measured by weighing the fish at an interval of 30 minutes until constant weight is obtained. The moisture content was evaluated on a dry weight or wet weight basis. Frequent checking of the fish was done to take precaution against charring of the product and get uniform heat, until the fish is completely smoked and dried. The fish was allowed to cool at ambient temperature before it was packaged in aluminum foil for preservation. While in IAK, the fish was hung vertically which allows them to drip any fluids or fats, thus facilitating much more rapid drying at 75°C. The top rods are secured to the roof and the lower ones hung from each other with simple hooks. This is a very efficient system allowing unimpeded air flow. In SBD, the fish was spread inside the box and drying was achieved by heat radiation from the sun through the polyurethane glass into the box that is painted black to absorb and retain heat. The fish was turned hourly to allow uniform drying. The drying efficiency (%) was determined using the differences in moisture loss and the time taken to dry. Organoleptic attributes of taste, texture, color, rancidity and general acceptability of the fish samples was evaluated by 10- untrained panelist, selected from the staff of Food Science Department, College of Agriculture, Jalingo, using a 9 - point hedonic scale (Adeyemi *et al.*, 2013). Means of data generated were represented using tables. Means were separated using the least significant differences (LSD) at 5%. Microsoft Excel and Genstat Ms Word packages were used.

RESULTS AND DISCUSSION

Proximate Composition of processed *Clarias gariepinus*

The proximate composition of *Clarias gariepinus* as affected by the different processors is presented in table 1. The proximate composition were significant ($P < 0.05$) as influenced by the different processing methods. The result showed that fish samples processed using IKDK indicated highest protein content (64.69%) in fillet Moringa and 56.2% in whole Ginger. In IAK, whole control revealed highest protein content of 56.7% and whole Moringa with 49.5% in SBD whole Ginger with 66.8% and whole control with 59.0% respectively. Fat content recorded highest value of 9.67% and 5.0% in whole Moringa and fillet Ginger in IKDK respectively. *Clarias gariepinus* processed with IAK 11.46% and 6.75% in whole control. While SBD processor recorded 11.72% for whole control and 11.4% for whole Moringa. Ash revealed higher values (9.0%) and the least in fillet Ginger with 1.5% for SBD.

Crude lipid recorded the highest value 17.75% in whole Ginger and 10.5% in fillet Moringa for IKDK Processor.

In Adrian kiln fillet Moringa has highest value of 22.1% and whole Ginger with 16.72%. Higher values of 14.4% was recorded for whole Moringa and 8.65% for whole Ginger in SBD fish processor.

The Dry matter of the IKDK has the highest value of 7.5 % in fillet Ginger and lowest 5.25% in whole Moringa. In the Adrian kiln (11.0%) was revealed for fillet Ginger and (5.5%) recorded in whole control. Also the SBD indicated higher (10.0%) in fillet control and the least (4.0%) fillet Moringa.

The NFE for the IKDK processor is (12.9%) in whole control and least in whole Moringa (1.6%). The result indicated highest NFE (6.5%) in whole Ginger and (1.14%) in fillet Moringa for the Adrian kiln. And in the SBD fillet Ginger recorded the highest with (7.4%) and 1.2% for whole Moringa.

Sensory Evaluation

The result of the taste panel for sensory attributes of Texture, Physical appearance, Taste, Aroma and rancidity was presented in Table 2. The table indicated that the texture of the control samples in SBD for WG is 7.52 ± 0.22 and 7.38 ± 0.11 for CW in IKDK and 7.09 ± 0.25 in the IAK was most preferred by the panelist. The physical appearance of the fish samples had the highest acceptance in the IAK with 7.19 ± 0.21 and 7.14 ± 0.33 for FC and CW respectively. In the IKDK also, the two samples CW and WG showed a slight difference of 7.29 ± 0.10 and 7.14 ± 0.19 respectively. While, in the SBD, CF showed the highest with 7.14 ± 0.09 . Taste scores indicated that samples

treated with Ginger had the highest acceptability in IAK with 7.86 ± 0.19 , 7.57 ± 0.11 and 7.33 ± 0.20 for FG, CF and WM respectively. For IKDK is 7.57 ± 0.11 , 7.43 ± 0.22 and 7.29 ± 0.14 for WG, WM and CW respectively. In the Solar Box dryer, FM recorded the highest acceptability of 6.90 ± 0.13 .

For Aroma, all the processors revealed that samples treated with Ginger exhibited highest acceptability scores and control samples showed the least values. In rancidity, there is no significant difference among the processors. However, the control samples showed some high degree of rancidity than the treated samples as indicated in the table (2).

The effect of smoke drying temperature and time on crude protein of the *C. gariepinus* showed that Crude protein increased with increase in temperature, time and the values obtained for the three processors. The reduced protein content in the Adrian processor had been earlier reported by several researchers Akinwunwi (2014); Longwe and Kapute (2016) and attributed it to the loss in available lysine. It is known that reduction in lysine is directly proportional to the temperature and duration of smoking as reported by Akande *et al.* (2000). Higher level of protein was observed in the Solar Box dryer as earlier reported by Chukwu and Shaba (2009).

Sun – dried fish had comparatively lowest moisture content and vice versa for fish that were smoked. It was also observed that protein levels increased with decreasing moisture content as earlier reported by Aliya *et al.* (2012). Highest and lowest Crude fat was obtained in SBD for whole control and for fillet Ginger in the IKDK. It is well reported that fat increases with heat processing and reduction in moisture content of fish (Akintola *et al.*, 2013, Oluborode *et al.* 2013), reduction in fat content of the processed fish could be due to the oxidation and breakdown of Crude fat into other components due to oxidation of poly unsaturated fatty acids (PUFA) contained in the fish tissue, such as peroxides, aldehydes, ketones and free fatty acids as earlier reported by Daramola *et al.* (2013). Reduction in fat could also be attributed to possible loss of fat due to high temperature (Idah and Nwankwo, 2013). Ash content is generally influenced by size of fish; smaller sized fish species tend to have higher ash content due to higher bone to flesh ratio as reported by Daramola *et al.* (2013). Lean fish have been reported to have high Ash content as observed by Kapute *et al.* (2013). High Ash content in IAK in this study could be due to size as well as loss of moisture. Sundried fish in this study appeared to have the least Ash content compared to the smoking kilns as previously reported by other authors Ahmed *et al.* (2011); Longwe and Kapute (2016).

Low and high moisture contents in smoked and dried samples could be attributed to differences in moisture of the smoked fish relative to the surroundings as suggested by Longwe and Kapute (2016). Lowest moisture (4.0%) in the SBD for fillet Moringa was within the acceptable limit for prevention of microbial spoilage as earlier reported by Immaculate *et al.* (2012), because water activity determines storage life of fish (Daramola *et al.* 2013). The sensory evaluation of food products to any food processing technology is very important in determining the consumer acceptability (Muhammad *et al.*, 2011). The result of the taste panel showed that there was no significant difference identified in all the sensory attributes as all the attributes fall within like slightly to like moderately as observed by Adeyemi *et al.* (2013). The texture of the fish samples indicated that the control samples especially in the IKDK was rated higher, followed by IAK. Aroma is the most important quality parameters of fish products. Samples treated with Ginger solution scored higher values in all the processors which agreed with the study of (Ade-Omowaye *et al.*, 2015) which showed that fish treated with Ginger has a good Aroma.

Taste is an important factor in consumers' acceptability. There is no much significant difference in the taste of all the samples in the processors. However, the samples processed with the IKDK indicated that control

and Ginger treated samples scored highest values as reported by Olayemi *et al.* (2013). Color, texture, flavor, nutritional composition and its shelf stability are common quality parameters for smoked fish (Horner, 2001). The overall rancidity of the processed samples indicated that control samples in the SBD had the highest degree of rancidity because the samples were not treated with any preservative as observed by Opara (2013). The overall acceptability of the fish for all the processors are within the conformity of the acceptable values as studied by Adeyemi *et al.* (2013).

From the analysis conducted, Moringa and Ginger have high preservative qualities. In conclusion, the use of preservatives is recommended in terms of Nutritional and sensory qualities to enhance the shelf life of the fish.

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Table 1: Proximate composition of processed *Clarias gariepinus* with different bio-preservatives and Processors

Processing method	Proximate composition of the processed <i>Clarias gariepinus</i>																	
	IMPROVED KAINJI KILN						IMPROVED ADRIAN KILN						SOLAR BOX DRYER					
	DM	CP	CL	ASH	CF	NFE	DM	CP	CL	ASH	CF	NFE	DM	CP	CL	ASH	CF	NFE
Whole Control	94.3	57.0	13.5	3.5	7.25	12.9	94.5	56.7	18.07	10.25	6.75	2.65	91.5	59.0	10.4	6.25	11.72	4.12
Fillet Control	93.0	61.25	13.5	3.5	6.25	8.5	94.0	53.25	20.15	8.5	9.45	2.65	90.0	60.13	13.2	5.5	9.45	1.72
Whole Ginger	92.8	56.2	17.75	7.75	7.47	3.52	90.0	29.2	16.72	7.25	7.37	6.5	94.0	66.8	8.65	3.75	8.67	6.1
Fillet Ginger	92.5	62.13	13.5	3.35	5.0	8.37	89.0	50.75	20.15	7.0	7.45	3.65	91.5	62.81	10.25	1.5	9.5	7.44
Whole Moringa	94.8	60.6	16.5	6.5	9.67	1.6	92.2	49.5	19.15	9.0	11.46	4.57	91.5	60.6	14.4	3.75	11.4	1.27
Fillet Moringa	93.5	64.69	10.5	7.55	8.5	4.26	91.5	50.31	22.1	8.5	9.45	1.14	96.0	64.5	11.55	9.0	9.5	1.39
SEM	99.6	1.19	0.91	0.92	0.77	2.00	98.9	4.84	0.66	0.59	0.87	0.72	99.4	1.38	1.05	0.82	0.59	1.20
Key; M = Moisture; CP = Crude Protein; CL = Crude Lipid; CF = Crude Fibre; NFE = Nitrogen Free Extract																		

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Table 2: Sensory evaluation of processed fish with the three processes

Sensory Attributes	C W	C F	WM	F M	W G	F G
Improved Adrian Kiln						
Texture	7.09±0.25	6.52±0.15	6.48±0.18	5.62±0.11	6.81±0.21	6.38±0.20
Physical appearance	7.14±0.33	7.19±0.21	6.05±0.16	6.00±0.29	6.23±0.14	6.38±0.22
Taste	5.86±0.19	7.57±0.11	7.33±0.20	7.05±0.18	6.95±0.24	7.86±0.19
Aroma	5.90±0.21	6.67±0.21	6.71±0.24	6.57±0.22	6.86±0.19	7.10±0.12
Rancidity	6.05±0.23	6.33±0.11	6.38±0.19	6.86±0.10	6.29±0.29	7.14±0.16
Improve Kainji Drum Kiln						
Texture	7.38±0.11	6.43±0.11	7.05±0.15	6.19±0.16	7.14±0.22	6.43±0.11
Physical appearance	7.29±0.10	6.71±0.10	6.71±0.15	6.43±0.11	7.14±0.14	6.29±0.20
Taste	7.29±0.14	7.19±0.18	7.43±0.22	6.81±0.15	7.57±0.11	7.00±0.20
Aroma	7.00±0.12	6.19±0.18	7.00±0.21	6.71±0.10	7.57±0.11	6.86±0.08
Rancidity	6.76±0.19	6.33±0.20	6.95±0.15	6.29±0.16	6.67±0.22	6.76±0.09
Solar Box Dryer						
Texture	6.43±0.20	6.43±0.22	6.85±0.26	6.38±0.18	7.52±0.22	7.00±0.17
Physical appearance	6.57±0.20	7.14±0.19	6.52±0.25	6.43±0.11	6.90±0.26	6.81±0.15
Taste	6.14±0.19	6.38±0.16	6.24±0.14	6.90±0.13	6.71±0.22	6.81±0.20
Aroma	6.43±0.16	6.42±0.19	5.86±0.08	5.87±0.34	7.00±0.29	6.43±0.11
Rancidity	5.86±0.14	6.19±0.13	6.33±0.28	6.33±0.22	6.00±0.15	6.09±0.13

Key: CW= control Whole, CF = control Fillet, WM = Whole Moringa, FM = Fillets Moringa, WG = Whole Ginger, FG = Fillet Ginger

PROXIMATE COMPOSITION, MICROBIAL CONTENT AND SENSORY EVALUATIONS OF SMOKED FARMED AND WILD CAUGHT AFRICAN CATFISH (*CLARIAS GARIEPINUS*) IN MAIDUGURI, NIGERIA"

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Abstract

Proximate composition and sensory quality of smoked farmed and wild catfish, *Clarias gariepinus* were determined using chemical, microbiological and sensory analyses. Proximate composition of both smoked farmed and wild catfish showed marked differences in moisture content, carbohydrate, crude fibre and ether extract levels. The smoked farmed catfish had high moisture content ($29.03 \pm 0.45\%$), crude fibre ($12.33 \pm 0.95\%$) and ether extract (16.30 ± 0.79) while high carbohydrate ($33.07 \pm 9.84\%$) was observed in the smoked pond-raised catfish. The total bacteria count in farm raised sample ($9.16 \pm 1.57 \times 10^3$ cfu/g) was slightly higher compared to wild capture sample ($8.23 \pm 1.35 \times 10^3$ cfu/g). No significant difference ($p > 0.05$) exists in the sensory scores between smoked-dried farmed and wild caught catfish. The wild captured sample was rated high in texture (3.10 ± 0.88) and taste (3.60 ± 0.97), while farm raised sample was rated high in appearance (3.7 ± 1.25). For odour, similar rating (3.80 ± 0.63) was realized in both farmed and wild caught catfish. These results thus, suggest that smoked catfish from both sources have similar nutritional and organoleptic quality.

Keywords: Proximate composition, Microbial contents, Sensory evaluation, African catfish

Introduction

Fish is an important part of a healthy diet with many nutritional benefits and is undoubtedly occupies one of the highest places on the food list of Nigerians (Olanrewaju *et al.*, 2015). It is consumed by all and sundry regardless of age, religion, and customs. Most people crave for fish in their diet due to its high nutritive quality and impacts on human health. Food fish is having a nutrient profile superior to all terrestrial meats (Olanrewaju *et al.*, 2010). It is an excellent source of high-quality animal protein and highly digestible energy as well as extremely rich source of Omega-3 polyunsaturated fatty-acids (PUFAs), fat-soluble vitamins (B complex), and minerals (calcium, phosphorus, iron, iodine and selenium). Fish is however available in many forms including live, fresh, chilled/frozen, smoked and dried due to advanced techniques in value addition (FAO, 2020).

African mud catfish, *Clarias gariepinus* is the most popular food fish supply from capture fisheries and culture ponds to the relish of the consumers in Nigeria. However, most consumers are of the opinion that the flesh quality of both wild-sourced and farm-raised catfish is not the same, which could be due to variations in their environmental condition, feed richness and availability. Ibadon *et al.*, (2015) noted that the reasons for this divergence belief are mainly due to tastes and safety. The opinion has advanced several researches to assess the superiority in their nutrient quality and which one is favoured. Some of the recent works on food fish quality between pond-raised and wild caught *C. gariepinus* gave credence to the pond-raised catfish for its better nutritional quality (Isangedighi *et al.*, 2017; Okonkwo *et al.*, 2020).

Information on proximate analysis of the fish indicates that their body composition varies with the season, environment, age, sex, feeding habits (Norouzi and Bagheri, 2015). More so, the smoking effects coupled with other factors could influence the nutritional quality and taste of fish. This understanding apart from the environments where the fish is sourced could also help the consumers to select better fish product. Several studies have been carried out to assess the smoking effects on the nutritional quality of *C. gariepinus* (Olopade *et al.*, 2011; Isangedighi *et al.*, 2017; Okonkwo *et al.*, 2020), but little is however known on this quality between smoked pond-raised and wild caught *C. gariepinus* especially in Maiduguri. Hence, the

current study aimed to assess the proximate composition, microbial and sensory quality of smoked pond-raised and wild caught *C. gariepinus*.

Materials and Methods

Experimental site

The study was carried out at Federal College of Freshwater Fisheries Technology (FCFFT) Baga, Borno State. The College was currently relocated and operating in Maiduguri where the NIOMR smoking kiln was used for the study.

Experimental fish and processing

Twenty live *Clarias gariepinus* (275.57 ± 24.13 g) each were sourced from Teaching and Research fish farm of FCFFT Baga and Lake Alau, all in Maiduguri for the experiment. The fish were stunned and killed following the method of Roth and Oines (2010). Thereafter, the fish were gutted, eviscerated, washed in clean water and immersed in 15% brine solution following the procedure of Ayeloja (2019). The experimental fish were grouped into two treatments representing farm-raised samples (FRS) and wild caught samples (WCS). Then, the fish were smoked-dried with no preservatives at a temperature of 80 ± 5 °C for 5h, cooled and stored at ambient temperature (28 ± 2 °C) for further analysis.

Proximate, microbial and sensory evaluation

The proximate compositions (moisture, protein, ether extract, ash, crude fibre, and carbohydrate) were assayed based on standard procedures of AOAC (2005). Each analysis was carried out in triplicates at the Analytical Laboratory, NAFDAC Office, Maiduguri, Borno State. Total bacteria counts were determined by Plate count agar (PCA) following APHA (1992) procedure. Taste panels of 10 members drawn among the staff of FCFFT, Baga who are already familiar with scoring of smoked fish were given the product to scores using a 5-point hedonic scale (5 - excellent, 4 - very good, 3 - good, 2 - fair, 1 - poor). This was undertaken to determine the taste, odour, mouth feel (texture) and general appearance (colour) of the Smoked fish products.

Statistical analysis

Data were analysed using descriptive statistics (means and standard deviations) and Analysis of Variance at $\alpha_{0.05}$.

Results and Discussion

The summary of proximate contents of smoked-dried farmed and wild caught *Clarias gariepinus* are as shown in Table 1. The mean moisture content ($29.03 \pm 0.45\%$), crude fibre ($12.33 \pm 0.95\%$) and ether extract (16.30 ± 0.79) of experimental fish showed significantly higher values in pond raised sample compared to the wild caught samples. More protein ($45.49 \pm 2.93\%$) and ash ($1.40 \pm 0.27\%$) contents were found in wild caught samples with significantly high carbohydrate ($33.07 \pm 9.84\%$). The results of the present study lend support to the findings of Okonkwo *et al.*, (2020) who reported slightly higher ash ($5.78 \pm 1.87\%$) and markedly high carbohydrate ($47.04 \pm 1.32\%$) contents in dried wild *C. gariepinus*. Similar observation was also reported by Adeosun *et al.* (2014) in crude protein values of iced wild and pond-raised *C. gariepinus* which differs non-significantly. However, Okonkwo *et al.*, (2020) and Isangedighi *et al.*, (2017) found significant higher protein contents in pond raised *C. gariepinus*. Figure 1 showed that total bacteria counts in farm raised sample ($9.16 \pm 1.57 \times 10^3$ cfu/g) was slightly higher compared to wild capture sample ($8.23 \pm 1.35 \times 10^3$ cfu/g). The results are in congruence with the work of Afolabi *et al.*, (2020) which shows that the total bacterial loads in pond-raised *C. gariepinus* were significantly higher than the total bacterial load recorded in wild *C. gariepinus*.

Table 1. Proximate contents (%) of smoked-dried farmed and wild caught catfish

Proximate composition	Samples		p-value
	FRS	WCS	
Moisture	29.03 ± 0.45	17.77 ± 2.46	0.00*
Protein	43.34 ± 2.90	45.49 ± 2.93	0.42

Carbohydrate	16.27±3.52	33.07±9.84	0.04*
Crude fibre	12.33±0.95	9.67±0.65	0.02*
Ether extract	16.30±0.79	9.77±0.91	0.00*
Ash	1.13±0.35	1.40±0.27	0.35

*p<0.05

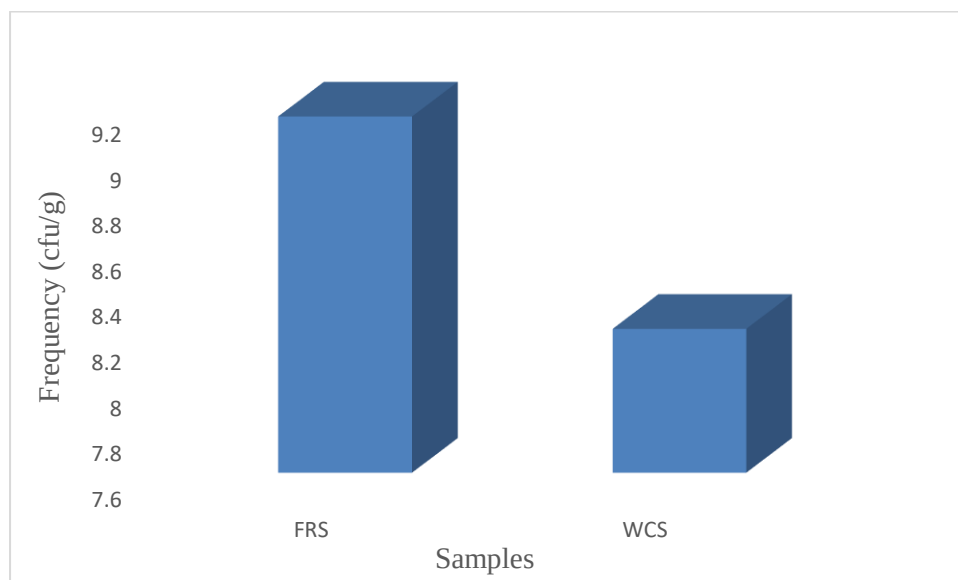


Figure 1. Total bacterial load (cfu/g) of smoked-dried farmed and wild caught catfish

It is evident that, no significant difference ($p>0.05$) exists in the sensory scores between smoked-dried farmed and wild caught catfish (Table 2). The wild captured sample was rated high in texture (3.10 ± 0.88) and taste (3.60 ± 0.97), while farm raised sample was rated high in appearance (3.7 ± 1.25). For odour, similar rating (3.80 ± 0.63) was realized in Treatments FRS and WCS.

Table 2. Panelist mean sensory scores for smoked-dried farmed and wild caught catfish

Sensory attributes	Samples		p-value
	FRS	WCS	
Appearance	3.7±1.25	2.90±1.45	0.20
Odour	3.80±0.63	3.80±0.79	1.00
Texture	2.60±1.43	3.10±0.88	0.36
Taste	2.90±0.99	3.60±0.97	0.13

*p<0.05

Conclusions

In conclusion, the present results show slight variations in crude protein and ash contents of smoked pond-raised and wild caught *C. gariepinus*. Also, the smoked fish from both sources revealed marginal variation on total bacteria count and sensory quality. These results thus, suggest that smoked catfish from both sources have similar nutritional and organoleptic quality.

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COMPARATIVE STUDY ON FISH PASTE AND MINCE FROM *LATES NILOTICUS* (Nile perch)

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ABSTRACT

Fish products (paste and mince) were produced from *Lates niloticus* obtained from Lake Kainji basin in Nigeria. The products were analysed for both nutrient content by AOAC, 2000 and sensory evaluation using hedonic scale of 0-5 rating. The results were subjected to Analysis of variance to compare the means for significant difference at ($P < 0.05$). The paste was found to have moisture content of 46.30 ± 0.73 , Ash content of 3.52 ± 1.44 , Fibre 1.13 ± 0.18 , crude protein 19.84 ± 1.65 , Fat, 25.63 ± 1.00 and NFE, 3.60 ± 1.75 while the mince had moisture to be 9.09 ± 0.61 , ash content 9.08 ± 0.32 , crude protein 46.49 ± 1.32 , fat content 19.95 ± 0.54 , while NFE is 13.89 ± 1.48 . The fish mince had the highest crude protein and NFE than fish paste. It is therefore suggested to consume more of fish mince for more of high crude protein and NFE with less fat content. Sensory evaluation of fish paste samples U1, U2, and U3 respectively showed there were no significant difference (5%) in colour, texture, flavour and taste (U1 3.80 ± 0.42 , U2 3.40 ± 0.52 and U3 3.40 ± 0.70) texture (U1 3.60 ± 0.52 , U2 3.80 ± 0.42 and U3 3.50 ± 0.71), flavor (U1 3.60 ± 0.70 , U2, 3.10 ± 0.57 and U3 3.10 ± 0.57) while taste value (U1 3.50 ± 0.71 , U2 2.70 ± 0.95 and U3 3.10 ± 0.88). Also the same in fish minces amples M1, M2 and M3 Colour (M1 3.80 ± 0.42 M2 3.80 ± 0.42 and M3 3.30 ± 0.82) texture (M1 3.00 ± 0.47 , M2 3.40 ± 0.52 and M3 3.10 ± 0.32) except in flavour value (M1 2.90 ± 0.57 M2 3.20 ± 0.79 and M3

2.80 $\pm$ 0.43) and taste (M13.20 $\pm$ 0.63, M2 2.40 $\pm$ 0.52 and 2.70 $\pm$ 0.48). There is significant difference in flavour and taste value respectively.

Keywords: Fish paste, Fish mince, *Lates niloticus*

INTRODUCTION

Fish is one of the numerous species among the vertebrate consisting of about 2000 species bird 8600 reptiles, 6000 mammals and amphibians 2500. Their shape range from streamlines to round shape while some are flat or triangular shape with their weight ranging from less than 1gram at adult stage that is clupeid to 140kg that is Nile perch (*Lates niloticus*) or 25metric tone example shark. Fish forms about 14% of the world consumption and animal protein and is very important part of animal protein in the diet of man and often provided the much needed nutrient that is not provided in cereal based diet (Clucas and Sutcliffe, 1981). Fish is rich in protein with amino acid composition well suited to human dietary requirement comparing favorably with eggs, meat and milk in the nutritional value of the its protein (Waterman, 1976). The Nile perch (*Lates niloticus*) is a species of freshwater fish in family latidae of order perciforme. It is widespread throughout much of the Afrotropicecozone, being native to Congo, Nile, Senegal, Niger and Lake Chad, Volta, Lake Turkan and other river basin. It also occur on brackish water of lake Maryut in Egypt originally described as *Labrius niloticus* among the marine grasses, the species has also been referred to as *Centroponus niloticus* common names include African Victoria Perch (a misleading trade name as the species is not native to Lake Victoria) and a large number of local name in various African language. In Hausa language it is called Giwanruwa meaning Water Elephant. *Lates niloticus* is silver in colour with a blue triage, it has distinctive dark-black eyes, with a bright-yellow outer ring one of the largest freshwater fish, it reaches a maximum length of nearly 2m (more than 6ft) weighing up to 2000kg (Azeroual *et al.*, 2010). Mature fish average 121-137cm(48-54mch) although many fish are caught before they can grow this large (Huss, 1998) Adult Nile Perch occupy all habitat of a lake with sufficient Oxygen concentration, while juvenile are restricted to shallow or near shore environment a fierce predator that dominate its surrounding, the Nile perch feeds on fish (including its own crustaceans and insect the juvenile also feed on zooplankton). Nile perch use schooling as a mechanism to protect themselves from other predator. The species is of great commercial importance as a food fish. This research was designed as a result of the monotony of stored fresh fish, the project source for variety of fish product other than stored fresh fish the most common method of preserving fish is by smoking. Fish can also be prepared in another way like pasting and mincing in order to add value to our product as value addition on our product is mostly appreciated in Nigeria. The aim of this project is to determine the nutritional composition and sensory evaluation of fish paste and mince from *Lates niloticus* and replace favorably other imported fish product that are over chemicalized

MATERIALS AND METHODS

Study Area

The study was carried out in the fish processing Laboratory of the Department of Fisheries Technology, Federal College of Freshwater Fisheries Technology (FCFFT), New Bussa, Niger State and analysis was done in the National Institute for Freshwater and Fisheries Research (NIFFR) Chemistry Laboratory using AOAC (2000).

Sources of Materials (Data Collection)

The fish *Lates niloticus* was purchased from Kaya; Kofa-dam near dam site along Mokwa road in New Bussa, Niger state. The fish was transported fresh in clean black polythene bag to the FCFFT processing laboratory. It was gutted and all debris were removed to avoid further deterioration, it was then stored in the processing freezer for 24hours the chopping board and some other wares like beaker, trays, muslin cloth and spatular were gotten from central laboratory of FCFFT, while some other materials like Pan, bowl, glass cup, groundnut oil, salt, pepper, corn flour and sharp knife were obtain from Monday market. Paper tape, sample bottle, disposal hand glove, nose mask and cotton wool were purchased from Tolu pharmaceutical store.

Fish Mince: The most common way of separating edible flesh from waste is by filleting, but a greater amount of flesh can be reserve in the form of a coarse mince by putting either the unfiletated fish or waste left after filleting, through a bone separator.

Sample preparation/ Procedures

The fish was brought out of the freezer after 24hours and it was washed with clean water placed on the chopping board which had been washed thoroughly with clean water. The fish was chopped into pieces (0.5-1cm)with sharp knife the pieces was mix with 4-5% of salt for 2kg of fish and the water 1:1(40-45°C) was added, the mixture was shaken, and the mixture was allowed to settle and lipid fraction was removed, the settled mixture is soaked for 20-30min in 4-5% salt solution, then sodium bicarbonate added to regularize the pH to 6.5-7 after which the fish were washed.

Fish Paste

Fish paste is fish which has been broken down by a fermentation process until it reaches the consistency of a soft creamy purse or paste; alternatively it refers to cooked fish. which has been physically broken down by pounding, grinding, pressing, mincing, blending, and/or sieving, until it reaches the consistency of paste(Larousse,2000).Monosodium glutamate (MSG) required to season food which is an advantage in food preparation. Fish paste is used as a condiment or seasoning to add flavor to food or in some cases to complement a dish. Chemically, fish paste is reduced to a thick, rich concentrate which has usually been cooked for long time. It can be contrasted with fish sauce, which is like a fish

Materials: The materials used for the study include; Fish (*Lates niloticus*) Knife, chopping board, glass cup, clean water,1.5g of salt for every 2kg of fish to be use,0.5 pepper,1.5 teaspoon corn flour and 6teaspoons of cold water, bowl, frying pan, disposable hand glove, sensitive weighing balance, nose mask, metal spoon and groundnut oil.

PROCEDURE OF SAMPLES PREPARATION

The fish kept in the freezer after 24hours was reclean again with clean water after which they were filleted both sides that is double filleting, the filleted fish was placed on the chopping board which has been washed with clean water and rinsed thoroughly, while filleting the fish water and salt were mixed thoroughly6teaspoons of clean water which was kept in fridge for some time, then after filleting the fish meat was scrap with the metal spoon and was chopped with knife. salt, pepper and corn flour in a small glass cup were mix and stirred thoroughly, mixture solution were then added gradually and chopped for a little while then was the remaining solution added and stirred in one direction as chopping continues until the fish paste become sticky the stirring continued for about 8-10 minutes after which the paste were gathered into the bowl and smacked against the bowl until paste is springy for about 3-4min the pack springy was placed into another bowl and it was allow to ferment for five minutes after which the fermented paste was fried and the sensory evaluation was carried out that same day. From the samples some species were taken for analysis in the chemistry laboratory of (NIFFR).

Statistical Analysis

Data were statistically analyzed using software program for social science (SPSS) Version 17.0; Independent sample T-test was used to compare the means of data for significant difference in proximate analysis. Analysis of variance (ANOVA) was used to compare the means for significant difference. Difference were accepted as significant at ($P < 0.05$)

Results and Discussion

Table 1: Shows the proximate composition of the samples

SAMPLES	MOISTURE%	ASH%	FIBRE%	PROTEIN%	FAT%	NFE%
A	46.30±0.73 ^a	3.52±1.44 ^b	1.13±0.18 ^a	19.84±1.65 ^b	25.63±1.00 ^a	3.60±1.75 ^b
B	9.09±0.61 ^b	9.08±0.32 ^a	1.51±23 ^a	46.49±1.32 ^a	19.95±0.54 ^b	13.89±1.48 ^a

MEAN ±Standard deviation with different superscript letter in a column differ significantly (P<0.05)

Table 2: Shows sensory evaluation of fish paste

TREATMENT	COLOUR	TEXTURE	FLAVOUR	TASTE
U1	3.80±0.42 ^a	3.60±0.52 ^a	3.60±0.70 ^a	3.50±0.71 ^a
U2	3.40±0.52 ^a	3.80±0.42 ^a	3.10±0.57 ^a	2.70±0.95 ^a
U3	3.40±0.70 ^a	3.50±0.71 ^a	3.10±0.57 ^a	3.10±0.88 ^a

MEAN ±Standard deviation with different superscript letter in a column differ significantly (P<0.05)

Table 3: Shows sensory evaluation of fish mince.

TREATMENT	COLOUR	TEXTURE	FLAVOUR	TASTE
M1	3.80±0.42 ^a	3.00±0.47 ^a	2.90±0.57 ^a	3.20±0.63 ^a
M2	3.80±0.42 ^a	3.40±0.52 ^a	3.20±0.79 ^a	2.40±0.52 ^b
M3	3.30±0.82 ^a	3.10±0.32 ^a	2.80±0.43 ^a	2.70±0.48 ^{ab}

MEAN ± Standard Deviation with different superscript letters in a column differ significantly (P<0.05)

The protein content of fish paste is 21.00% while that of fish mince is 47.42% therefore it shows that the protein content in fish mince is higher, it is then advisable to eat more of fish mince because of its higher protein content (Eyo,1992). We all know how important protein is to our body its help renew and repair our body tissues which are constantly undergoing wear and tear such tissues are found in the sole of our feet, nails, hair and skin. The proximate composition show that protein content in fish mince is higher (46.47±1.32) and is significantly different showing that protein content is also higher in the statistical analysis. The sensory score also shows that fish mince was widely accepted and can be used as one of the ingredients for preparing food attributing to it taste, colour and aroma.(Table 2&3) According to (FAO,2008a) to get fish paste with high protein content, one should use small fishes because the concentration of protein is high, while in fish mince one should use fish with high fat content such as *Clarias* and *Lates niloticus* because the fat is eliminated to some extent in order to maintain a particular fat content, this is because some people do not like much fat in food and also much fat consumption in older people is health risk as fat increases the blood pressure. It was also revealed that frying is the best method of preserving fish mince but is good for growing up children. Paste except it is not cooked for so long is a thick liquid rather than a concentrated fish like mince and may include seasoning and other flavouring. During low fishing period sometimes fishers use their abundant catch of small fish to make fermented fish paste and smoked fish with the assistance of family member (FAO, 2008b).

CONCLUSION

The study revealed that fish mince has high protein content. Frying of fish also concentrated and increased the nutritional value of fish since most of the moisture are lost during the process. The overall preference and protein content value of fish is higher in fish mince and it is encouraged to be consumed. The study also revealed that although frying of fish is good but it should not be consume in high quantity by the elderly. Fatty food is good for the children but not too good because of high blood pressure for older people whereas in paste fish, fat has been remove to attain a particular fat content which the body requires.

RECOMMENDATION

It is recommended that fish mince maybe eaten by both young and old people because of the presence of high percentage of crude protein and low crude fat content that are needed for the replacement of worn-out tissue in human body system.

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TECHNIQUES AND TECHNOLOGIES FOR FISH PROCESSING AND PRESERVATION AROUND KAINJI LAKE BASIN, NIGERIA - A REVIEW

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ABSTRACT

Fish is particularly a perishable food stuff and required preservation for future uses. Several techniques and technologies are used over the world to process and preserve fish with specific aim of prolonging the shelf-life of the fish. These techniques are routinely employed by the fisher folks depending on the availability of the technologies. Fish processors around Kainji Lake Basin are known of processing and preserving fish traditionally. Therefore, this paper seeks to review the known traditional methods and some modern technologies that are available for fish processing and preservation in the area.

Keywords: Fish processing, Fish preservation, Kainji lake Basin, Techniques and Technologies

INTRODUCTION

Fish is an important source of food, revenue, and employment for people around the world and it is a very essential source of animal protein for both man and livestock in developing countries (Emmanuel *et al.*, 2014). Fish is an extremely perishable food item and required preservation for future uses. Several preservation methods are employed over the world for preserving fish. The intention of all these methods is to extend the shelf-life of fish so that the fish can be used in future. Various traditional methods had been employed to preserve and process fish for consumption and storage in an effort to extend its shelf-life. These include smoking, drying, salting, frying, fermentation and combination of these. In Nigeria, fish smoking is the most widely practiced method. Practically, all species of fish available in the country can be smoked. It has been estimated that 70-80% of freshwater catch and from aquaculture are consumed in smoked form (Akinola *et al.*, 2016).

Fresh fish when out of water deteriorate fast except immediate step are taken to preserve its quality, despite the subsistence nature of our capture fisheries in Nigeria. Tawari (2016) also reported that most of the fish processing community in Nigeria employed traditional techniques and they have been in existence for more than ten years. As much as 50% post harvest losses are recorded, the result of this is economic losses to fish farmers, fish processors and marketers is quite enormous.

The need to mechanised fish processing technique has drawn the attention of national agricultural research to devote utmost interest and resources to engineering research in fish processing operation, to reduce labour operation and unsanitary fish handling procedures that may be involve in fish smoking operations. (Ayubaet *al.*, 2020). Thus it is imperative to process and preserve some of the fish caught in the period of abundance, so as to ensure an all year round supply. This will invariably reduce post harvest loses, increase the shelf life of fish, and guarantee a sustainable supply of fish during off season with concomitant increase in the profit of the fish entrepreneurs (Eyo, 2002). Therefore, this paper presents literature review of few of the technologies available for fish processing and preservation around Kainji Lake basin.

FRAMEWORK

The general process employed by fishermen for processing and preserving their catches (fish) in capture fisheries usually follows the following:

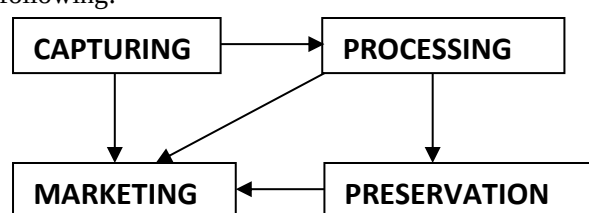


Fig. 1 Generalized Framework for marketing fish by fishermen (Author, 2022)

1. **Capturing:** This is the process by which fish is being catch from the river or from stocked water bodies. This process is achieved by the used of various techniques which includes netting, angling and trapping, trawling or the use of other fishing gear technologies.
2. **Processing:** The processing is the stage where fish caught from the river or aquaculture is prepared for preserving or marketing at their freshness depending on the choice of the processor. At this stage, fish handling which includes sorting and grading, gutting and washing, chilling and brining are carried out (Bate and Bendall, 2010). The processing (handling) determine the quality of the fish at the end of the production process. If fish is not handled properly in this stage, bacterial, enzymatic and chemical action can sets in before it is preserve.
3. **Preservation:** This is the stage in postharvest where processing and preservation techniques and technologies are applied to extend the shelf life of fish. This includes freezing, canning, smoking, salting and sun-drying (Adeyeye et al. 2015).
4. **Marketing:** Fish marketing is the activity of distributing goods and services (fish) from producer (fisherman) to consumer (buyer). Efficient fish marketing system is the indicator that is representing the overall growth and development of fisheries sector (FAO. 2001). The fisherman take their catches (raw fresh or processed and preserved) to market where retailers meet them and bargain by the lot. In Nigeria, particularly the southwestern region, women primarily process and market both fresh and processed fish (Babalola et al. 2015).

LITERATURE REVIEW

1. FISH PROCESSING AND PRESERVATION TECHNIQUES

SALTING

Salting is a traditional method of fish processing in many countries of the world. It can be used in combination with drying or smoking as a pre-processing process. Salting the fish removes water and lowers the water activity (water available for the support of microbial growth which causes the spoilage). Water is the main culprit in spoiling food. When moisture is completely removed from the food, spoiling is arrested. The practices of preserving fish for bleak days through salt curing and sun drying are very common at places near the seashore since ancient times. Salt curing means preserving the flesh by applying salt to it and

drawing out the moisture. The salt curing fish is more popular than sun drying as the latter is not possible in colder areas and it greatly changes the properties of the food. Salt curing is done with dry salt and is very close to pickling which involves using brine water solution for preservation. The fish becomes completely dry when salt-cured and needs to be soaked in potable water before cooking. Eyo, A.A (2002)

SMOKING

Fish smoking is the most widely and accepted means of preserving fish for consumption and commercialization. In Nigeria, smoking is the most practiced preservation method; practically every species of finfish available in the country can be smoked (Adeyeye et al. 2015). Over 30% of the fish harvested from aquaculture fisheries are preserved by smoke drying, especially in rural areas, often lack cold storage facilities (King 2003). Smoking fish can also enhance the taste, flavor and thus the economic value of the products (Akinpelu et al. 2013). The process of smoking occurs through the use of fire wood. Experience has shown that hardwood is better than the soft woods.

Babanna and Abdulrahman (2013) conducted a study to modify the existing smoking equipment and the heat source used for fish smoking in New Bussa area, the result showed that some woods imparted the best result (colour, texture, taste and flavor) to smoked fish, few imparted good colour but poor flavor and others produced dark brown colour and good flavor.

Omojowoet *et al.*, (2016) conducted a survey around North west and North east region of Nigeria and reported that the major fish processing method was fish smoking accounting for 95% of the sample. Fish smoking is the traditional occupation of the artisanal fishermen and women in Nigeria with simple traditional ovens.

SUNDRYING

Although fish smoking is the most popular method of post-harvest processing and preservation in developing countries, studies show that Polycyclic Aromatic Hydrocarbons (PAHs) level in smoked fish is higher than the permissible limit (more than 5 micrograms per kilogram) set by USA and European Food Safety Authority and are therefore either seized, returned or destroyed at the destination port (Iwuoha, 2013). Sun drying is one of the oldest known methods of preserving perishable food items including fish. In Nigeria, sun drying is the most widely used method of fish preservation because it is considered as the least expensive method of preservation. Example, in northern Nigeria, sun drying is favored because of the dry weather conditions, low humidity and shortage of firewood. Fish are laid to dry on tarpaulin sheets, raised nets or floor platforms (Bradley B., *et al.*, 2020). According to Adeogun and Adebisi-Adelani (2016), it is common for clupeids to be sundried because fire-based processing often destroys them, given their small size. Generally, there are two commonly terms used in drying of fish namely sun drying and dehydration.

FREEZING

Fish freezing is a process of preservation in which the temperature of fish and fishery products is lowered at 40°C or below with most of the water inside of fish tissue turning into ice. Icing and chilling can keep the fish for a few weeks only. Fish is required to be kept for longer periods, for example to even out supplies during gluts, to enable fish to be distributed and sold in distant markets, and to stock pile products for lean seasons. Eyo, A.A (2012)

Icing is most effective if the full surface of the fish is in contact with ice. Therefore, the smaller the ice the faster and better the chilling rate and the coarser the ice the slower is the chilling rate. If ice is improperly applied on fish, then it will take a much longer time for the temperature of the fish to attain 0°C. This could have the same effect as delayed icing. For example, it has been reported that a 5cm thick layer of fish placed in a box with ice only at the top will take up to 18hrs before the fish flesh in contact with the bottom of the box reaches 0°C. The same fish packed in NIFFR fish ice Box on all sides will reach 10°C in about 5hrs (Iluahi *et al.*, 2015).

2. TECHNOLOGIES USED FOR FISH PROCESSING AND PRESERVATION

TRADITIONAL BANDA:

The traditional Banda smoking kiln is type of kiln that is locally constructed using mud sand and sticks, it is usually circular in shape with the sticks cross across the opening to serve as a tray, it has a chamber with a stoked hole without specific dimension, firewood is the only source of energy for its operation. The traditional Banda have the advantage of being of low capital cost while the disadvantages include: Constant attention for its operation. (i.e its operation is time consuming), The operation is both health and fire hazard, inept in their use of fuel and ventilation system, no control over the temperature of the oven, High density of smoke is produced, limited durability of materials used, exposure of the fish to climatic conditions and insect attack, and final product from the oven is of poor quality (Olorokor, *et al.*, 2017). The Banda kiln can

be improved by expanding the size, increases in diameter of the walls for heat retention and additional racks for increase batch capacity in other to have good quality smoked fish at the end of fish processing.



Plate 1: Traditional Banda



Plate 2: Modernize Banda Kiln

- **MODIFIED DRUM SMOKING KILN**

The modified drum smoking kiln is a modification of the traditional rectangular mud type smoking kiln. This modification has a simple structure and can be constructed by the local fish processor. This kiln is constructed using metal drum and contains a frame zinc cover with chimney that served as an escape route for excess smoke, it possesses two set of trays where fish is loaded for smoking, a small fire box with a dimension of 30cm x 30cm which allowed limited air ingress and escape of smoke, also a perforated circular metal plate that disallowed direct contact of the fish with fire called damper. It uses firewood as source of fuel for smoking. Its efficiency and utilization capacity of fuel hasten its adoption by the local processor in the area. The merit of the modified drum kiln is that it produces better quality smoked fish as compared to the traditional type, transportation from one location to another is easy, and limited processing time is achieved. High rate of body heat conductivity which usually caused loss of heat during operation is its demerit and low batch capacity for large fish processor.



Plate 3: Modified Drum Kiln

- **KAINJI GAS KILN**

The gas kiln possesses structural framework of angle bars and hollow pipes with dimension of 0.92 x 0.76 x 1.24 cm. the smoking chamber is of dimension 0.66 x 0.76 x 0.94 cm and adjacent to the smoking chamber are chest of drawers where sawdust and wood shavings are burnt. Under the smoking chamber is the furnace where burning butane gas generates heat to the smoking chamber. The entire framework of the kiln is covered with a steel plate which is perforated at the top with a pipe connected from inside the chamber to form the chimney. The smoking chamber also contains 5 mesh trays where fish is loaded. The kiln uses butane gas as source of heat for its operation.

The combination of smoke from wood shavings and heat from burning butane gas produced smokes fish that are more attractive than those smoked traditionally. (Eyo, 2002) invented the Kainji gas kiln and was patented by NIFFR, New Bussa, Niger State. A comparison study on the performance of the Kainji gas kiln with other commonly used smoking kiln was done by Eyo (2002); the result of the study showed that fish smoked with Kainji gas kiln has the best taste, flavor, appearance and the overall acceptability. The better quality of fish smoked with Kainji gas kiln was attributed to the fact that smoke is generated externally which prevented contamination of the smoked fish with tar, soot and other smoked particles from the burning sawdust and woods. The challenges with the use of Kainji gas kiln is the high cost of butane gas which is not affordable to most of the fish processors. In the light of the above, NIFFR hybrid kiln was developed

- **NIFFR/WAAPP HYBRID KILN**

The NIFFR/WAAPP Hybrid smoking kilns is a rectangular shaped kiln with dimension (1.2m x 0.8m x 1.2m). The smoking kiln has a double wall structure properly insulated with the inner and outer wall made

of galvanize metal plate. The kiln is divided into two chambers; one chamber can be used for charcoal fuel energy while the other chamber can be used for firewood fuel energy. This makes it hybrid in nature. The kiln also has a stainless steel damper which serves as a receptacle for the collection of melted fats as well as prevents the direct contact of fire with the fish. Studies conducted with the kiln revealed that maximum temperature obtained for charcoal and wood were 200°C and 150°C respectively (Okouzi and Ayuba, 2014). The hybrid kiln is presently used in NIFFR and many fish farmers across the country where they all testify on its effectiveness in processing of good quality smoked fish.

• SOLAR TENT DRIER

To preserve forest resources around Lake Kainji, Olorok (2003) has designed, constructed and tested a simple reproducible solar tent dryer which fully depends on solar energy for its operation and can also serve as an alternative to smoking kiln for dried fish products. The construction of the tent was done using four sticks of 18cm in diameter, holes of length 12cm were dug into the ground and the sticks were fastened by ropes to form the shape of a tent. A sewn transparent polyethylene sheet of 500 gauges was draped over the frame to serve as greenhouse medium that allows solar energy through it but traps the terrestrial energy to heat up the chamber below it. This heating coupled with the black rocks arranged around the base of the dryer, which causes drought condition in the chamber leading to the drying of the fresh fish placed on the drying racks inside the chamber. The leading advantages of the solar tent drier are outlined as thus: It is simple and easily reproducible, produces better dried fish than the usual open sun drying, highly efficient and clean products are produced, it does not require supervision during its operation and products from the solar tent dryer can be stored for long time. The modified rectangular passive greenhouse dryer has been found to effectively dry *Latesniloticus*, *Clariasgariepinus* and *Clariasanguillaris* in NIFFR New Bussa Okouzi, *et al.*, (2015) to the moisture content which prevents autolysis process, bacterial spoilage as well as the oxidation process that will allow for the storage of the products without spoilage. Analysis of the aquaculture value chain revealed that the most popular method of post-harvest processing and preservation of fish in developing countries like Nigeria are by drying (Omojowoet *al.*, 2015).

The disadvantages as at then to be mentioned were: It only depends on solar energy; it is not movable to another location and inadequate solar energy can cause spoilage of fresh fish. These challenges have however been overcome and the dryer improved such that it is now detachable to enable its relocation, more drying racks included for capacity and the dryer has been able to dry other additional commercially important freshwater fish species (Okouzi *et al.*, 2019 and 2020).

• RETAIL TABLE

The traditional way of selling fish in the market by retailers is usually done by displaying both the fresh and the smoked fish on an open table which exposed the fish to flies, insects, dust and other contaminants. Therefore, the need for the modern retail table. The retail table is a framed wire netting box table constructed using a 1 x 1 (inch) square pipe with dimension of 4ft x 2ft x 2ft. At one side of the table is an opening with dimension 2ft x 1.5ft provided for putting and removing of fish. A galvanized plate of same dimension is used to cover the down part of the table. This is where the fish are loaded for marketing. The good feature of the table is that buyers do not have access to touch the fish while buying and the use of net disallows flies and other insects to get contact with the fish. The retail tables are presently in use by some fish processors in Kanji Lake basin area and fish processors in Katsina state as it was distributed to them by WAPP Nigeria in 2016.



Plate 4: fish Retail table



• WOODEN ICE BOX

Artisanal fisher folk are known for storing their catches inside fishing boats where they lie in a pool of warm dirty water and become contaminated with micro-organisms; hence the need for the design of a wooden ice box for preserving their fresh catches. (Eyo, 1998) has designed an insulated container suitable for use by artisanal fisher folks in small fishing boats using locally sourced materials. The box consists of two layers of 6mm marine plywood dovetailed and glued together with cascarumite glue and insulated with expanded

polystyrene. The outer dimension of the box is 61 x 46 x 30.5 cm while the inner dimension is 53 x 38 x 26.5 cm. Between the inner and the outer space is polystyrene of thickness 2.5cm with a flush finish at the top. Its lid lies at the top with its insulated part recessed about 2.5cm into the inner box. The box is coated with glass flake, 2 pack epoxy paint on all sides to reduce moisture penetration to the wood. A ½ cm diameter plastic drain cock is fitted at the bottom through the inner part and lift studs are secured on both end of the outer part of the box. The flat lid allows the box to be stacked in the fishing vessel thus, minimizing encroachment on space. The defect of the box is absorption of moisture by the wood which gives room to micro-organisms contaminating the fresh catches. Hence the need for the construction of the aluminum ice cooling box. (Ihuahi *et al.*, 2015)

• ALUMINUM ICE COOLING BOX

Ihuahi, *et al.* (2015), has constructed the aluminum ice cooling box as an improvement on the wooden ice box. The ice cooling box is made up of aluminum sheet with a dimension of 600mm x 400mm x 400mm. the inner and the outer surfaces are covered with aluminum to prevent both the bruising of the fish and the tendency of water absorption from the melted ice, as is the case with the wooden type. The box is properly insulated with Styrofoam to minimize heat exchange between the inside and the outside surrounding of the box. This enhances freshness extension of the fish and minimizes microbial growth during storage. At the bottom of the box is a drainage hole that is provided to prevent accumulation of fish water by draining melted ice from fish. The boxes are used by fish farmers across kainji lake basin for fish handling on the landing site and are used to transport fresh fish from one location to another



Plate 5: Aluminum Ice Cooling Box

CONCLUSION

Fish preservation and processing is a very important part in fisheries industry. Fish capturing sites are usually located far away from market sites and there is chance of fish decomposition hence Preservation and processing, therefore become a very important part in commercial fisheries. It is done in such a manner that the fishes remain fresh for a long time, with a minimum loss of flavor, taste, odour, and nutritive value. This is achieved by the proper use of techniques and technologies.

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EFFECTS OF ONION AND GARLIC OILS ON PROXIMATE COMPOSITION AND ORGANOLEPTIC CHARACTERISTICS OF SMOKED AFRICAN CATFISH (*CLARIAS GARIEPINUS*, BURCHELL 1822)

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ABSTRACT

The proximate and organoleptic quality effects of onion and ginger oils on smoked *Clarias gariepinus* were investigated. Twenty-one (21) fresh *C. gariepinus* (285.56±2.25 g) were procured and sorted into three treatments representing onion oil treated fish (OOF), garlic oil treated fish (GOF), and no oil treated fish (NOF). Each treatment was smoked separately using NIOMR smoking kiln with charcoal as its heat source. Proximate composition and sensory evaluation were analyzed following standard procedure. Data were analysed using descriptive statistics and ANOVA at $\alpha_{0.05}$. Results from proximate analysis showed highest significant dry matter (87.34±0.05 %) and minimum moisture content (12.67±0.05 %) in NOF. Crude protein (42.06±0.01 %) and ash (2.03±0.06 %) level was markedly highest in GOF. Highest carbohydrate (36.01±0.46 %) level was obtained in OOF. Highest acceptability in appearance (4.67±0.50), odour (4.33±0.50) and taste (4.44±0.53) were revealed in NOF, while GOF has higher fish texture (4.00±1.12). The study revealed linear increment in crude protein and ash content as well as better consumer acceptability to fish texture in GOF. It is therefore recommended that further study be carried out on the effect of onion oil and ginger oil on smoked fish shelf life.

Keywords: *Clarias gariepinus*, proximate composition, Organoleptic properties, essential oils, smoking

INTRODUCTION

African catfish, *Clarias gariepinus* is an indigenous fish to Nigeria with good nutritional value and adequate market demand (Olanrewaju *et al.*, 2015). It is a highly valued food fish widely accepted in Nigeria due to its unique taste, flavor and texture. The fish is usually available in many forms including live, fresh, smoked and dried due to advanced techniques in fish processing and value addition. However, smoked catfish is very popular and it has become a delicacy enjoyed throughout many countries in West Africa, especially in Nigeria. It is a recipe that has made its way into the stews and soups of many Nigerian homes and Nigeria food lists. It is usually prepared by drying the fish in a smoking kiln in order to preserve and flavor it. The reasons for fish smoking are varied, but in Nigeria, the process has proven relevant to prolonging shelf-life, enhancing flavor and increasing protein availability to people throughout the year (Kumolu-Johnson and Ndimele, 2011).

Smoking is one of the traditional methods of preserving fish and other food products as it inhibits microbial growth and delays the oxidative changes (Fuentes *et al.*, 2010). In addition to the combined effects of preservation, drying, and cooking of smoking, certain organoleptic characteristics (taste, colour, aroma and texture) and enhanced proximate quality can also be achieved. Erkan (2010) noted that smoked food has special flavor and color that can improve the sensory characteristics and the commercial value of a food product. Hence, several attempts have been made by researchers to improve the smoking quality of African catfish, *Clarias gariepinus* for the enjoyment of consumers both locally and abroad.

Fish smoking method has advanced with the use of herbs and spices including onion, garlic, leek, nutmeg, peppers and ginger etc. to increase its storage period and nutritional properties. Fish processed with spices before smoking usually comes with beneficial effect on the overall quality of the final product. However, no different spices give the same result due to their varying biochemical constituents. The essential oils from ginger, *Allium sativum* and onion, *Allium cepa* have been identified as new potential source of natural anti-microbial and anti-oxidant agent applied in the food system (Ibrahim, 2010). Meanwhile, there is scanty of information regarding the impact of essential oils on the proximate and organoleptic quality of smoked *C. gariepinus*. This study therefore focused on the effect of onion and garlic oils on organoleptic and proximate quality of hot smoked *C. gariepinus*.

Materials and Methods

Experimental Site

This study was carried out at the processing Unit of Federal College of Freshwater Fisheries Technology Baga, Borno State, temporarily relocated at NIFFR Zonal Office, Maiduguri. It is located in North-Eastern part of Nigeria at Latitude 11°5' N and Longitude 30°5' E.

Samples Collection

Twenty-one (21) fresh *Clarias gariepinus* (285.56±2.25 g) were bought from Teaching and Research Farm, Federal College of Freshwater Fisheries Technology, Baga, Borno State. The fish were transported in a bucket to the processing site within the College premises. An Egyptian company, El-Hawag preservative spices (onion and garlic oils) were bought from Monday Market, Maiduguri Borno State. The oil samples were in 30ml bottles.

Experimental procedure

The fish samples collected were stunned and killed following the method of Roth and Oines (2010). It was thoroughly washed against slime, ecto-parasites and bacterial. It was further grafted and left for 40 minutes to drain water from the body. The experimental fish were grouped into three treatments representing Onion oil treated fish (OOF), Garlic oil treated fish (GOF), and No oil treated fish (NOF). The OOF and GOF were treated with Onion oil and Garlic oil of 1.5ml/kg respectively while OOF was not treated with oil as control. Each treatment was smoked separately using NIOMR smoking kiln with charcoal as its heat source. After smoking, three fish samples were collected randomly from each treatment and transported in separate carton to National Agency of Foods and Drugs Administration Control (NAFDAC), Maiduguri office for proximate analysis. The remaining fish were used for taste, appearance and texture analysis as ten (10) trained panelists were brought to assess the fish following 5-point hedonic scale (5 - excellent, 4 - very good, 3 - good, 2 - fair, 1 - poor).

Data analysis

Data generated were subjected to both descriptive (means and standard deviations) and inferential statistics (ANOVA) at $\alpha_{0.05}$. Duncan's Multiple Range Test (DMRT) was applied to separate differences in treatment means.

Results and Discussion

The results on the proximate composition of the freshly processed onion and garlic oils treated smoke-dried *Clarias gariepinus* are presented in table 1. The results show that the highest mean dry matter (87.34 ± 0.05 %) was obtained in Treatment NOF (control), followed by Treatment GOF (82.61 ± 0.05 %) (garlic oil), while Treatment OOF (onion oil) had the least (76.52 ± 0.04 %). There is significant difference ($p < 0.05$) in percentage dry matter values between the treatments. Similarly, mean moisture content ranged between 12.67 ± 0.05 % in control and 23.49 ± 0.04 % in Onion oil treated fish. There exist significant differences between the treatments. Similar observation was recorded when oven drying *Citharinus citharus* was treated with *Piper guineense* and *Zingiber officinale* (Agbabiaka *et al.*, 2016). Garlic oil treated fish (GOF) revealed significant highest crude protein level (42.06 ± 0.01 %) as compared to Onion oil treated fish (28.97 ± 0.06 %) and Control (39.78 ± 0.01 %). According to Nwinuka *et al.* (2005), the linearly improved crude protein concentration with spices fortification might be due to additional nutrients inherent in ginger.

Table 1. Proximate composition (%) of freshly processed onion and garlic oil treated smoke-dried *Clarias gariepinus*

Compositions	Treatments		
	OOF	NOF	GOF
Dry matter	$76.52 \pm 0.04_c$	$87.34 \pm 0.05_a$	$82.61 \pm 0.05_b$
Moisture content	$23.49 \pm 0.04_a$	$12.67 \pm 0.05_c$	$17.39 \pm 0.05_b$
Crude protein	$28.97 \pm 0.06_c$	$39.78 \pm 0.01_b$	$42.06 \pm 0.01_a$
Crude fat	$6.50 \pm 0.50_c$	$11.50 \pm 0.50_a$	$8.99 \pm 2.19_b$
Crude fibre	$10.50 \pm 0.50_b$	$12.50 \pm 0.50_a$	$12.33 \pm 0.58_a$
Ash	$0.97 \pm 0.06_b$	$1.50 \pm 0.50_{ab}$	$2.03 \pm 0.06_a$
Carbohydrate	$36.01 \pm 0.46_a$	$33.56 \pm 0.05_b$	$28.06 \pm 0.45_c$

The crude protein boost in ginger oil treated fish in this study is in congruence with the findings of Agbabiaka *et al.* (2016) who reported increased protein contents in black pepper and ginger treated *Citharinus citharus*. Similar observation was also recorded by Ayeloja *et al.* (2013) in hot-smoked *Clarias gariepinus* treated with different spices.

Crude fat showed that Control had the highest mean value of 11.50 ± 0.50 %, while Treatment OOF recorded the lowest mean crude fat of 6.50 ± 0.50 %. The results of ANOVA showed that the difference in mean crude fat readings between the treatment was significant ($p < 0.05$). The crude fibre content was significantly higher ($p < 0.05$) in Treatments NOF (12.50 ± 0.50 %) and GOF (12.33 ± 0.58 %) than treatment OOF (10.50 ± 0.50 %). Ash content ranged between 0.97 ± 0.06 % and 2.03 ± 0.06 % in all the treatments. The results show that the highest mean ash (2.03 ± 0.06 %) was obtained in Treatment GOF, followed by Treatment NOF (1.50 ± 0.50 %), while Treatment OOF had the least (0.97 ± 0.06 %). Analysis of variance revealed marked difference ($p < 0.05$) in ash content between treatments. Also, results showed that highest mean carbohydrate value with 36.01 ± 0.46 % was obtained in Treatment OOF, while the lowest value of 28.06 ± 0.45 % was found at Treatment GOF. This observation contradicts the result of Ayeloja *et al.* (2013) who studied effect of spices on the chemical properties of hot-smoked *Clarias gariepinus*. These authors found significant higher moisture content (6.18 ± 0.15 %), protein (79.44 ± 0.13 %), lipid (6.31 ± 0.19 %) and ash (7.04 ± 0.14) for no spice-treated smoked African catfish, *Clarias gariepinus* while ginger-spiced fish had markedly higher crude fibre (10.54 ± 0.23 %).

The results of sensorial analysis for the freshly processed onion and garlic oil treated smoke-dried *Clarias gariepinus* was shown in table 2. The appearance in NOF (Control) was excellent (4.67 ± 0.50) and appears significantly better than Treatments OOF (4.22 ± 0.44) and GOF (3.78 ± 0.97). The odour in studied fish was notably ($p > 0.05$) very good in Treatment NOF (4.33 ± 0.50) followed by GOF (4.00 ± 0.71) and OOF (3.89 ± 0.78). For taste, the highest value (4.44 ± 0.53) was realized in Treatment NOF, followed by Treatment

OOF (4.22 ± 0.97) while least grade value (3.89 ± 0.93) was found in Treatment GOF. However, there is significant difference ($P > 0.05$) for the values obtained for taste between treatments. The result showed that Treatments OOF and NOF received similar panel scores of 3.89 ± 0.78 and 3.89 ± 0.60 respectively while GOF showed slightly higher value of 4.00 ± 1.12 , in texture. The sensory evaluation results in this study were in agreement with the findings of Agbabiaka *et al.* (2016) for oven drying *Citharinus citharus* treated with black pepper and ginger. In contrast, the results obtained by Adibe *et al.*, (2018) revealed that *Clarias gariepinus* treated with Onion extract gave the most desirable results in terms of taste, appearance, flavor and general acceptability.

Table 2. Organoleptic properties of freshly processed onion and garlic oil treated smoke-dried *Clarias gariepinus*

Compositions	Treatments		
	OOF	NOF	GOF
Appearance	$4.22 \pm 0.44_{ab}$	$4.67 \pm 0.50_a$	$3.78 \pm 0.97_b$
Odour	$3.89 \pm 0.78_b$	$4.33 \pm 0.50_a$	$4.00 \pm 0.71_{ab}$
Taste	$4.22 \pm 0.97_a$	$4.44 \pm 0.53_a$	$3.89 \pm 0.93_b$
Texture	$3.89 \pm 0.78_a$	$3.89 \pm 0.60_a$	$4.00 \pm 1.12_a$

Conclusion

The study revealed linear increment crude protein and ash content in ginger oil treated fish as well as better consumer acceptability to fish texture. It is therefore recommended that further study be carried out on the effect of onion oil and ginger oil on the fish shelf life.

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INSECT PESTS OF DRIED AND CURED FISH PRODUCTS OF GARKAWA MARKET IN MIKANG LGA OF PLATEAU STATE.

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ABSTRACT

The genera of fish identified were *Hydrocynus*, *Clarias*, *Hemichromis*, *Alestes*, *Momyrus*, *Synodontis*, *Labeo*, *Citharinus*, *Bagrus*, *Tilapia*, *Polepterus*, *Petrocephalus*, *Heterotis* and one unidentified heap. While the only insect pest identified was *Demestes spp* with more larval forms (2454, 89.70%) compared to the adult *Demestes* (282, 10.30%). There were significantly difference at ($p < 0.05$) for all the parameters considered in a completely randomized design. The WOFBI of *Tilapia spp* and *Synodontis spp* (71.00a) were significantly similar and higher than the unidentified heap (39.00b) > *Clarias* (34.00c) > *Labeo spp* (22.00d) with *Hemichromis spp* (4.00fg) as the least. The WOFBI of *Synodontis spp* (62.00a) > *Tilapia* (55.00b) > Unidentified (33.00c) > *Clarias spp* (30.00d) with *Hemichromis* recording the least weight of 2.00h. But in terms of weight lost, *Tilapia spp* recorded the highest weight lost of 16g > *Synodontis spp* (9g) > Unidentified (6g) > *Labeo spp* (5g) > *Momyrus* = *Clarias spp* (4g) while the others were negligible. *Tilapia* also had the highest infestation rate (43.00a) by adult *Demestes* which was significantly higher than *Synodontis* = *Labeo* = *Clarias* were statistically the same but higher than *Bagrus spp* and *Petrocephalus* as the least. For *Demestes* larvae infestation, *Tilapia spp* had 206.00a > *Labeo spp* (136.00b) > *Bagrus* (108.00c) > *Synodontis spp* (87.00d) > *Clarias spp* (78.00e) > *Petrocephalus spp* (44f) with *Hemichromis* recording least larval forms of 3.00n. Fish genera that were more susceptible to *Demestes* infestation were *Tilapia spp*, *Labeo spp*, *Bagrus spp*, *Synodontis* and *Clarias spp*. While the less susceptible ones were *Petrocephalus*, *Heterotis*, *Momyrus*, *Citharinus*, Unidentified, *Alestes*, *Hydrocynus*, *Polypterus* and *Hemichromis*. Significant differences in weight losses and insect infestation indicated net reduction in the amount of nutrients available to consumers (nutritive qualitative) leading to declining consumers acceptability and market price (economic losses) or both qualitative and quantitative losses. This could cause the retail value of fish to increase beyond the purchasing power of the poor. Therefore proper preservation and processing methods should be embarked on.; Activities of fish vendors and fish sellers should be properly checked by veterinarians and public health officers.

Key Words; Insect Pests, Dried, cured Fish and Infestation

INTRODUCTION

Dried fish produce an excellent source of protein in the diets of many families throughout the world, (Eyo, 2001). Anon (2001) stated that the sun drying of fish in combination with salting, result in products that are highly relished by people who prefer its characteristics flavor, taste and texture. Dried fishery products suffer severe losses due to infestation by flesh flies (sarcophagidae), beetles (*Demestes*, *Cornestes* and *Necrobia* species); and mites (*lardoglyphus* and *lyrophagus* species) (shiv, et al.,2018); this infestation are heavy in dried products depending on the duration of storage, the salt content, humidity, weather condition and general conditions of hygiene (Owoade,2008). Johnson, et al., (2007) stated that insects eat away the muscles leaving the skeleton when dry fishes are stored for long period leading to the reduction in the amount of nutrients and both quantitative and qualitative losses resulting to decline consumer acceptability of market prices (Tehera, et al., 2016). Length of storage is the main cause of fish infestation by insects (Bolevane-Quatinam, et al.,2015). Dried fish contaminated by both insects and harmful insecticides comprises about 80% of the total products that is considered unfit for human consumption. The losses have been attributed to net reduction in the amount of nutrient available to consumers.(Atijegbe, 2004), causing the retail value of fish to increase beyond the purchasing power of the poor (Wahedi & Kefas., 2013). Activities of fish vendors such as sprinkling water on dried fish promotes insect pests growth and suitable breeding grounds (Odeyemi, et al.,2000).There are limited studies on the activities of fish vendors, insect infestation of dried fish and fish processing especially in the southern zone. Of Plateau State were Garkawa is located. Hence the systematic investigation of the various insect pests infesting dried fish in Garkawa will be of immense benefit to both fish sellers and consumers in the study area.

MATERIALS AND METHOD

Study Area The research was carried out in the Biology Laboratory of Plateau State College of Agriculture Garkawa. Garkawa is located in the Northern Guinea savannah ecological zone (Latitude 10° 11¹ N and longitude 8° 211¹ E) in Mikang Local Government Area in the Southern part of Plateau State (Badi,2013).

Sampling of Dried/Cured Fish. Samples of different types of dried/cured fish sold in Garkawa market were purchased from different fish stalls at random. Each collection was tight in polythene bags and brought to the Biology Laboratory of College of Agriculture Garkawa. The samples were then exposed and identification of fish done to generic level using taxonomic method according to (Lawan, 1976; Holden & Read. 1971). Each genera of fish identified was weighed after replication and later tight in polythene bags and stored for six weeks (5th, April to 23rd, May). Weight of fish before infestation was 914.25g with average weight of 304.75g

Sampling of Insect Pests on Dried/ Cured fish. After six weeks of storage of the different genera of dried fish, each was exposed on an illuminated surface and were visually examined with the naked eyes, later with hand lenses and light microscope (Eke, *et al.*, 2008). The insects wriggled out of the dried fish were collected in separate containers and analyzed in the laboratory. The residue (left over) of the different Genera were weight again amounting to 723g with average weight of 241g

Counting and Identification of Insect Pests. The adults and larvae of Insect pest collected from the different fish Genera were counted and indentified into possible taxonomic levels based on their morphological features as stated by shiv, *et al.*, (2018) and Eyo, (2001).

Data Analysis. The experimental design was the completely randomized design. Data collected was analyzed with a one way analysis of variance (ANOVA) using SSPS 2010, with accepting significant difference at $p < 0.05$. The following parameters were considered, Weight of fish before infestation, weight of fish after infestation, adult insect pests and larvae of insect pest. Each parameter was replicated into three while the fish genera serve as treatment.

RESULT AND DISCUSSION.

Thirteen genera of fish were identified in addition to one unidentified heap (broken pieces). The genera of fish identified were *Hydrocynus*, *Clarias*, *Hemichromis*, *Alestes*, *Momyrus*, *Synodontis*, *Labeo*, *Citharinus*, *Bagrus*, *Tilapia*, *Polepterus*, *Petrocephalus* and *Heterotis*. *Demestes spp* (adult and larvae) was the only insect identified, this corresponds to the work of Bolevane Quantinam, *et al.*, (2015) who recognized *Demestes* as the main insect pest infesting fish in Bangui. Tehera, *et al.*, (2008) also recognizes *Demestes* and *Necrobia* as pests of stored fish products. More larval forms of *Demestes* (2454, 89.70%) were identified compared to the adult *Demestes* (282, 10.30%) which disagrees with the work of Wahedi & Kefas (2013) who identified more adult insects.

From Table I, it can be seen that means on the same raw with different superscripts are significantly different at ($p < 0.05$); with superscript “a” higher than superscript “b” in descending order. The WOFBI of *Tilapia spp* and *Synodontis spp* (71.00a) were significantly similar and higher than the unidentified heap (39.00b) > *Clarias* (34.00c) > *Labeo spp* (22.00d) with *Hemichromis spp* (4.00fg) as the least. WOFBI of *Synodontis spp* (62.00a) > *Tilapia* (55.00b) > Unidentified (33.00c) > *Clarias spp* (30.00d) with *Hemichromis* recording the least weight of 2.00h. But in terms of weight lost, *Tilapia spp* recorded the highest weight lost of 16g > *Synodontis spp* (9g) > Unidentified (6g) > *Labeo spp* (5g) > *Momyrus* = *Clarias spp* (4g) while the others were negligible. *Tilapia* also had the highest infestation rate (43.00a) by adult *demestes* which is significantly higher than *Synodontis* = *Labeo* = *Clarias* which were statistically the same but higher than *Bagrus spp* and *Petrocephalus* as the least. Likewise in terms of *demestes* larvae infestation, *Tilapia spp* had 206.00a > *Labeo ssp* (136.00b) > *Bagrus* (108.00c) > *Synodontis spp* (87.00d) > *Clarias spp* (78.00e) > *Petrocephalus spp* (44f) with *Hemichromis* recording least larval forms of 3.00n.

Table I: Summary of insect infestation of fish genera collected from Garkawa Market. Means identified by different superscripts are significantly different (0.05)

Fish Genera	WOFBI	WOFAI	AD	DL
<i>Hydrocynus spp</i>	7.75 ^f	5.00 ^g	0.00 ^e	13.00 ^l
<i>Clarias spp</i>	34.00 ^c	30.00 ^d	11.00 ^b	78.00 ^e
<i>Hemichromis spp</i>	4.00 ^g	2.00 ^h	0.00 ^e	3.00 ⁿ
<i>Alestes spp</i>	11.00 ^e	8.00 ^f	1.00 ^{ef}	20.00 ^k
<i>Momyrus spp</i>	6.00 ^{fg}	2.00 ^h	1.00 ^{ef}	31.00 ^h
<i>Synodontis spp</i>	71.00 ^a	62.00 ^a	12.00 ^b	87.00 ^d
<i>Labeo spp</i>	22.00 ^d	17.00 ^e	12.00 ^b	136.00 ^b
<i>Citharinus spp</i>	8.00 ^f	5.00 ^g	0.00 ^e	28.00 ⁱ
<i>Bagrus spp</i>	12.00 ^e	9.00 ^f	8.00 ^c	108.00 ^c
<i>Tilapia spp</i>	71.00 ^a	55.00 ^b	43.00 ^a	206.00 ^a
<i>Unidentified spp</i>	39.00 ^b	33.00 ^c	2.00 ^{de}	24.00 ^m
<i>Polypterus spp</i>	6.00 ^{fg}	5.00 ^g	0.00 ^e	7.00 ^m
<i>Petrocephalus spp</i>	7.00 ^f	4.00 ^g	1.00 ^{ef}	44.00 ^f
<i>Heterotis</i>	6.00 ^{fg}	4.00 ^g	3.00 ^d	33.00 ^g
SEM	22.87	19.59	11.18	56.85
P. Value	0.00	0.00	0.00	0.00

Key: WOFBI = 1ST Weight of fish (g) before infestation, WOFAI = 2nd weight of fish (g) after infestation, AD = Adult Dermestes, DL = Dermestes larva

On a general note, fish genera that were more sensitive to *Demestes* infestation were *Tilapia spp*, *Labeo spp*, *Bagrus spp*, *Synodontis* and *Clarias spp*. While the less susceptible genera to *Demestes* infestation included *Petrocephalus*, *Heterotis*, *Momyrus*, *Citharinus*, *Unidentified*, *Alestes*, *Hydrocynus*, *Polypterus* and *Hemichromis*. This disagrees with the work of Owaode (2008) who observed that dried fish species of *Districhodis mossambicus*, *Clarias gariecilis*, *Polydactylus quandrifilis*, *Cyprinus carpio* and *Hydrocynus goliath* were favorable to the development of *Demestes*; and the less sensitive were *Oreochromis mossambicus*, *Momyrus rume* and *Synodontis nigrita*. Also Bolevane-quantinum (2015) stated that the most sensitive of dried fish to attack by *Demestes* were *Oreochromis mossambicus*, *Momyrus rume* and *Synodontis nigrita*. These differences would have resulted due to differences in environmental conditions. Weight lost of fish after infestation agreed with the work of Shiv, *et al.*, (2018) who stated that dried fishery products suffer severe losses due to infestation by flesh flies, beetles and mites. Eke, *et al.*, (2008) further buttress that dried fish suffer considerable loss in weight of up to 50% due to beetle damage during storage.

CONCLUSION.

The genera of fish identified were *Hydrocynus*, *Clarias*, *Hemichromis*, *Alestes*, *Momyrus*, *Synodontis*, *Labeo*, *Citharinus*, *Bagrus*, *Tilapia*, *Polepterus*, *Petrocephalus*, *Heterotis* and one unidentified heap. While the only insect pest identified was *Demestes spp* with more larval forms (2454, 89.70%) compared to the adult *Demestes* (282, 10.30%). There were significantly difference at (p<0.05) for all the parameters considered. The WOFBI of *Tilapia spp* and *Synodontis spp* (71.00a) were significantly similar and higher than the unidentified heap (39.00b) > *Clarias* (34.00c) > *Labeo spp* (22.00d) with *Hemichromis spp* (4.00fg) as the least. The WOFAI of *Synodontis spp* (62.00a) > *Tilapia* (55.00b) > *Unidentified* (33.00c) > *Clarias spp* (30.00d) with *Hemichromis* recording the least weight of 2.00h. But in terms of weight lost, *Tilapia spp* recorded the highest weight lost of 16g > *Synodontis spp* (9g) > *Unidentified* (6g) > *Labeo spp* (5g) > *Momyrus* = *Clarias spp* (4g) while the others were negligible. *Tilapia* also had the highest infestation rate (43.00a) by adult *Demestes* which was significantly higher than *Synodontis* = *Labeo* = *Clarias* were statistically the same but higher than *Bagrus* and *Petrocephalus* as the least. Likewise in terms of *Demestis* larvae infestation, *Tilapia spp* had 206.00a > *Labeo spp* (136.00b) > *Bagrus* (108.00c) > *Synodontis spp*

(87.00d) > *Clarias spp* (78.00e) > *Petrocephalus spp* (44f) with *Hemichromis* recording least larval forms of 3.00n.

On a general note, fish genera that were more sensitive to *Demestes* infestation were *Tilapia spp*, *Labeo spp*, *Bagrus spp*, *Synodontis* and *Clarias spp*. While the less susceptible genera to *Demestes* infestation include *Petrocephalus*, *Heterotis*, *Momyrus*, *Citharinus*, Unidentified, *Alestes*, *Hydrocynus*, *Polypterus* and *Hemichromis*. Significant differences in weight losses and insect infestation indicated net reduction in the amount of nutrients available to consumers (nutritive qualitative) leading to declining consumers acceptability and market price (economic losses) or both qualitative and quantitative losses. This could cause the retail value of fish to increase beyond the purchasing power of the poor. Therefore proper preservation and processing methods should be embarked on.; Activities of fish vendors and fish sellers should be properly checked by veterinarians and public health officers.

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GREENHOUSE DRYING OF ADDITIONAL COMMERCIALY IMPORTANT FRESHWATER FISH SPECIES IN KAINJI, NIGERIA

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ABSTRACT

Fish is highly perishable and, if not properly treated after capturing/harvesting, it becomes unfit to eat, dangerous to health through microbial growth, chemical change and breakdown by endogenous enzymes and leads to post-harvest losses which affect the four dimensions of food security (availability, access, stability and utilization). In this study, the improved greenhouse dryer was evaluated in drying additional commercially important freshwater fish species in Kainji, New Bussa, Niger State. Two commercially important freshwater fish species (*Bagrus bayad* and *Lates niloticus*) were obtained from the wide (capture fishery) while other two commercially important freshwater fish species (*Clarias gariepinus* and *Clarias anguillaris*) were obtained from aquaculture system. These were prepared for drying. The improved greenhouse dryer was found to be capable of drying additional commercially important freshwater fish species to moisture content indicated [*Bagrus bayad* (23.41%), *Lates niloticus* (12.60%), *Clarias gariepinus* (16.80%) and *Clarias anguillaries* (17.76%)]. These prevent autolysis, microbial spoilage and oxidation processes thus, allowing for the storage of the solar dried fish to meet quality standard suitable for export.

Key words: Freshwater fish, Kainji, Solar energy, Passive greenhouse drying,

Introduction

Fisheries and aquaculture are a source not just of health but also of wealth. However, the perishability of fish makes it more susceptible to losses in hot tropical developing countries like Nigeria. As in any food system, such losses of fish affect the four dimensions of food security vis-à-vis availability, access, stability and utilization (FAO, 2014). Accordingly, the socio-economic impact of post-harvest losses is significant because the post-harvest domain comprises several activities at all stages of the supply chain among which are processing, preservation, storage and distribution. In many developing countries, processing uses less-sophisticated methods of transformation which provide livelihood support to large numbers of people in coastal areas and probably will remain important components in rural economies structured to promote rural development and poverty alleviation. Hence, availability of solar energy for drying led to the optimization of the rectangular passive greenhouse dryer as the most appropriate technology applied in order to make it sustainable, maximize its advantage and optimize the efficiency of drying using solar radiation (Hii *et al.*, 2012 and WCED, 1987).

Greenhouse dryer (Solar tent) is a class of solar thermal devices which are solar energy technologies for conversion of solar radiation into heat using solar energy collectors (Tiwari, 2003 and Olorok, 2004). The energy from solar radiation is free, renewable and abundant in any part of the world especially in developing countries (WEC, 2004). Nigeria situated in the high solar radiation belt of the world receives an average solar radiation of about 7.0kWh/m²-day (25.2MJ/m²-day) in the far north and about 3.5kWh/m²day (12.6MJ/m²-day) in the coastal latitude (Ileoje, 1997 and Ilenikhena and Ezemonye, 2010) which offers a good opportunity for using solar dryers in many locations. However, it has been observed in Olorok (2004) that the shortcomings of the Kainji solar tent dryer as observed by users in the field besides its low capacity also includes its inability to dry other freshwater fish species except *Bagrus bayad*. Drying fish in the rectangular passive dryers (solar tent dryer and smoking kiln) also enhances the scaling of the fish drying process as a result of the multiple racks arranged vertically. Thus, a limited space can be used for drying large quantities. However, studies have shown that fish smoking has health and environmental implications some of which include cancer from the carcinogenic components of wood smoke mainly polycyclic aromatic hydrocarbons (PAHs) and derivatives of PAH, causing skin and sight problem, affect the male and female reproductive system and still birth common among women who process fish (Akpoghelie, 2018; Ezike and Ohen, 2018; Yussuf *et al.*, 2015; Silva *et al.*, 2011 and Feka and Manzano, 2008). These studies further

revealed that PAHs level in smoked fish is higher than the permissible limit (more than 5 micrograms per kilogram) established by USA and European Food Safety Authority (EFSA) and are therefore either seized, returned or destroyed at the destination ports (Iwuoha, 2013). Consequently, the presence of these carcinogenic components in smoked fish makes it not acceptable in international market (EFSA, 2010, 2009 and 2005). Similarly, the high temperature dryers used in commercial production are found to be economically viable in developing countries only on large agro sectors and generally they are not affordable by small and medium entrepreneurs because of high cost and process variability. Hence, the introduction of cost effective and locally manufactured solar dryers is sustainable and provides a promising alternative to reduce the enormous post-harvest losses. The opportunity to produce high quality marketable solar dried fish products for domestic consumption and possibly for export appears to be a chance to improve the economic situation of the farmers as well as earn foreign exchange for the country. The broad objective of the study is to determine the effectiveness of the improved rectangular passive greenhouse dryer in the drying of additional commercially important freshwater fish species in Nigeria.

Materials and Methods

The experimental location Kainji, New Bussa has the following geographical coordinates: 9° 53' 0" (9.883°) North and 4° 31' 0" (4.517°) East. The improved rectangular passive greenhouse dryer used for this study is shown in Plate 1 which was modified and improved by computer-aided engineering (CAE) analyses approach involving computational fluids dynamics (CFD) simulation of the batch process in the rectangular passive greenhouse dryer (Okouzi *et al.*, 2020), and responds surface methodology (RSM) optimization (Okouzi *et al.*, 2021). The production of the different joint on the rectangular passive greenhouse dryer structural frame was built to ASME Codes using anthropometrics and welding procedures specifications (WPS).



Plate 1: Optimized Rectangular Passive Greenhouse Dryer

The major modification on the rectangular passive greenhouse include a redesign and specification of the flow surface (inlet and outlet vents) and the relocation of the drying racks to between the inlet and outlet vents observed to be the portion of the greenhouse dryer that supports effective drying based on the results of the computational fluids dynamic simulation and response surface methodology optimization of the dryer. The commercially important freshwater fish species dried in this study were selected from the wide (*Bagrus bayad* and *Lates niloticus*) as well as from aquaculture system (*Clarias gariepinus* and *Clarias anguillaris*). *Clarias gariepinus* and *Clarias anguillaris* were bought from Abdusallam farm, New Bussa while *Bagrus bayad* and *Lates niloticus* were sourced from Awuru.

The sample fish were prepared following the procedures by Weiss and Buchinger, (2012) as presented in Plates A.1 to A.5 in Appendix A. A major step in the fish preparation process (see Plate 2-4) is the cutting of the fish transversely as shown in Plates A2 and A3 instead of the usual longitudinal cutting as in Olorokor (2004). The percentage concentration of the natural preservative used (garlic, onion and ginger) was estimated using the formulae (Adeyemi *et al.*, 2014):

$$\% \text{ Concentration} = \frac{\text{Weight of additive (g)}}{\text{Volume of water (ml)}} \times 100 \quad (1)$$

The drying experiments were conducted at the NIFFR fisheries technology laboratory complex in the month of October, 2018. The modified NIFFR greenhouse dryer was employed in the drying process. Mass of the

dried fish was determined using a weighing balance so as to evaluate the drying characteristics of the four species dried.

The change in mass of the samples was observed until the mass change became constant. The moisture content $x(\%wb)$ was then calculated as a difference between the initial and final mass from the relation:

$$x = \frac{\text{Initial mass} - \text{Final mass}}{\text{Initial mass}} \times 100[\%wb] \quad (2)$$

The drying rate was also determined from the relation:

$$\text{Drying rate} = \frac{\text{Initial mass} - \text{Final mass}}{\text{Time interval}} [kg/hr] \quad (3)$$

Results and Discussion

The optimization of the batch process in the rectangular passive greenhouse dryer indicated that there is a range of distance between the inlet vent and the outlet vents within which there is temperature increase in the dryer. Hence, this is the portion of the greenhouse dryer that supports effective drying. The temperature observed within the rectangular passive greenhouse dryer falls within the temperature range (45 to 50°C) that tropical species of fish can generally withstand before proteins are denatured or cooking starts (Weiss and Buchinger, 2012). The relocation of the drying racks at appropriate distances between the inlet vent and the outlet vent enhanced effective drying of additional commercially important freshwater fish species as presented in Appendix A. The final Moisture content and drying rate of the additional four commercially important freshwater fish species (*Bagrus bayad*, *Lates niloticus*, *Clarias gariepinus* and *Clarias anguillaris*) dried in the greenhouse dryer are presented in Table 1.

Table 1: Greenhouse Drying Characteristics of Four Commercially Important Freshwater Fish Species

Characteristics	<i>Bagrus bayad</i>	<i>Lates niloticus</i>	<i>Clarias gariepinus</i>	<i>Clarias anguillaries</i>
Initial Weight (kg)	2.7500	2.7500	2.7500	2.7500
Weight After 5 hours (Day 1)	1.4342	0.6253	1.2450	1.0252
Weight After 12 hours (Day 2)	0.8452	0.3224	0.6836	0.5012
Weight After 18 hours (Day3)	0.6438	0.3466	0.4621	0.4883
Final Moisture Content (%)	23.4109	12.6036	16.8036	17.7564
Drying rate (kg/hr)	0.1170	0.1271	0.1335	0.1257

Moisture content is an important factor determining the shelf life of dried fish. *Lates niloticus* was observed to have the lowest final moisture content within the drying period of 18 hours of sunshine. Within the drying period, the moisture content of all the species were reduced below 25% (w.b) for fish given by Weiss and Buchinger (2012) at which contaminating agents cannot survive and autolytic (self-destruction by enzymes in the fish body which also affects the fish flavour) activity is greatly reduced. However, within the drying period, only the moisture content of *Lates niloticus* was reduced below 15% at which mould growth is prevented during storage. This implies that in the month of October in Kainji, more drying period (sunshine hours) is required to dry other species to the moisture content that inhibit the growth of mould during storage. However, the result in the month of October (wet season) justifies that the passive greenhouse dryer will be more effective in the hotter months in Kainji.

Fish weight loss (drying rate) expressed as the difference between the fresh and dried fish mass in the greenhouse dryer as a result of moisture loss from the fish is shown in Figure 1.

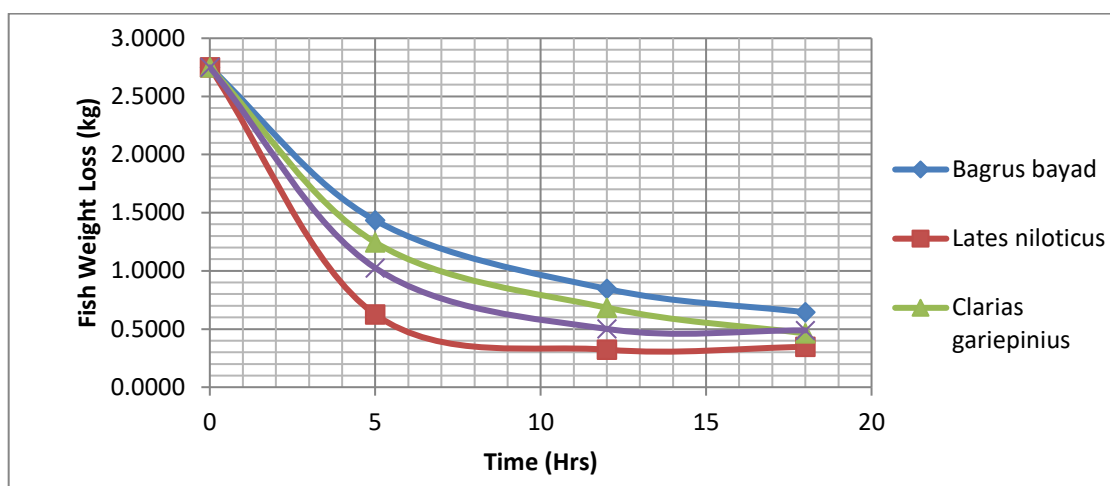


Figure 1: Fish Weight Loss in Passive Greenhouse Dryer (October, 2018)

Figure 1 indicates that *Lates niloticus* also attained the constant weight change status in the second day (after 9 hours of drying) before other species which could have been responsible for the extent of drying achieved. However, according to Assefa *et al.* (2008) fish weight loss during drying is affected by other factors such as season, apart from dryer type. Generally, while *Lates niloticus*, *Clarias gariepinus* and *Clarias anguillaris* were observed not to have oil during and after the drying period, *Bagrus bayad* was observed to be oily during and after drying which could have possibly be responsible for its lowest drying rate and highest final moisture content with oil inhibiting drying by evaporation.

CONCLUSION

The improved rectangular passive greenhouse dryer has been found to effectively dry additional commercially important freshwater fish species (*Bagrus bayad*, *Lates niloticus*, *Clarias gariepinus* and *Clarias anguillaris*) in Kainji to the moisture content at which contaminating agents cannot survive, which prevent autolysis process, bacterial spoilage as well as the oxidation processes thus, allow for the storage of the solar dried fish products without spoilage. However, the stability of dried food products during storage depends on the ease with which the food can pick up moisture from the air apart from moisture content of the dried product. Therefore, following the successful drying of additional commercially important freshwater fish species (*Bagrus bayad*, *Lates niloticus*, *Clarias gariepinus* and *Clarias anguillaris*) using the improved rectangular passive greenhouse dryer, studies of the shelf-life stability of these products under different packaging conditions is further recommended. Quality evaluation which includes sensory, microbiological and chemical evaluations should be integrated within the product development process to allow cost-effective delivery of acceptable solar dried fish products to consumers and thus reduce the risk of failure.

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ANALYSIS OF MICROBIAL LOAD OF *CLARIAS GARIEPINUS* SMOKED WITH DIFFERENT WOOD TYPES IN MAIDUGURI METROPOLIS

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ABSTRACT

The analysis of microbial load of *Clarias gariepinus* smoked with different wood types in Maiduguri Metropolis was carried out. This study aimed at investigating the effects of microbial load on *Clarias gariepinus* smoked with *Prosopis africana*, *Anogeissus leiocarpus*, and *Guinea selegalesis*, finding out the palatability of smoked *Clarias gariepinus* with the various fuel wood types and evaluating the storage stability of the smoked sample.

Thirty (30) fresh *Clarias gariepinus* were procured from a reputable fish farm in Maiduguri, Borno State using sterile plastic bags and transported under refrigeration to the processing unit of Federal College Freshwater Fisheries Technology Baga, Maiduguri. Samples were washed, spread to dry and distributed to the three smoking kilns each having the three different fuel wood types: *Prosopis africana*, Guinea senegalesis and *Anogeissus leiocarpus*. Heat was applied for eight and half hours and the fish allowed to dry. Part of the samples was used for sensory test using 42 students of the college while some samples were taken to the microbiology laboratory of the department of veterinary medicine, University of Maiduguri for microbial analysis as described by Collins Lyne (1970). Bacterial count was determined using nutrient agar methods. Total bacterial count was highest in *Guinea senegalesis* (12×10^3 cfu/ml) and the lowest was observed in sample treated with *Anogeissus leiocarpus* (5×10^3 cfu/ml). Sample smoked with *Prosopis africana* have an excellent aroma (Odour), texture and appearance while fish smoked with Guinea senegalesis has the lowest aroma, texture and appearance. Fish smoked with *Anogeissus leiocarpus* had highest storage stability (shelf- live) while sample smoked by *Guinea senegalesis* had the least storage stability.

Key words: *Clarias gariepinus*, smoking, wood types and Maiduguri Metropolis

INTRODUCTION

Fish has become an increasingly important source of protein and other nutrients necessary for the maintenance of healthy body. The nutrient composition of fish varies greatly from one species to another depending on age, sex, environment and season. In developing countries, fish is a relatively cheap and accessible protein source, suitable for complementing high carbohydrate based diets especially in West African population. (Adeyeye *et al.*, 2015; Ikutegbe and Sikoki, 2014).

Millions of bacteria are present in the surface skin, gill and intestines of live fish, although the flesh itself is normally sterile. Bacterial growth and invasion on the fish are prevented by the body's natural defense system during life but after death, the defense system breaks down and the bacteria multiply and invade the flesh. And also immediately fish dies, it remains in first class quality only for a short while (Clucas and Ward, 2016). However, spoilage soon sets in occasioned by an increase in the ambient temperature that triggers favorable conditions for microorganisms to thrive

Adadu and Ochogwu (2020) stated that bacteria (*Staphylococcus aureus*), yeasts (*Aeccharomyces cerevisiae*) and Moulds (*Penicillium* and *Aspergillus*) were the commonest microorganisms associated with smoked fish. Scientists have shown that the contamination of food of fish origin with pathogenic *Escherichia coli*, probably occur during handling of fish and production process (Aberoumand, 2010). Fish and Fish products are involved in 10% - 20% of food borne diseases (Pilet and Leroi, 2011). And the presence of pathogenic bacteria such as *Staphylococcus aureus*, *Salmonella sp*; some types of *E. coli*, and *Listeria monocytogenes* have been reported in smoked fish (Adeyeye *et al.*, 2015).

Apart from giving the product a desirable taste and odour, smoking provides a longer shelf life through its anti-bacterial and oxidative effect, lowering of pH, impacting desirable colouration as well as accelerating the drying process and acting as antagonist to spoilage agents (Eyo, 2001).

Over the time, several fuel woods have been used in smoking fish which has enhanced palatability, but the microbial content (load) increases. Hence, the choice of these fuel woods to enhance reduction in microbial load to a tolerable level.

This study aimed at investigating the effects of microbial load on *Clarias gariepinus* smoked with *Prosopis africana*, *Anogeissus leiocarpus*, and *Guinea selegalese*, finding out the palatability of smoked *Clarias gariepinus* with the various fuel wood types and evaluating the storage stability of the smoked sample.

Materials and Methods

Study Area

Maiduguri is the Capital of Borno State. It is located in the Sahel Savannah region of North-East Nigeria at Latitude 11° 48 N to 11° 50 and longitudes 13°06 E to 13°14 E at an altitude of 345M above the sea level. It has a total of approximated land area of 69,436 square kilometers. The climate of Maiduguri is favorable, with a mean annual temperature of 32°C (Adadu and Ochogwu, 2020).

Sample Collection

Thirty (30) fresh *Clarias gariepinus* weighing 300-500g and length of 32-35cm were obtained from a reputable fish farm in Maiduguri Borno State Nigeria.

Sample Preparation Procedure

The fish were degutted, washed thoroughly, and then divided into three batches and kept on a fish rack to drip for few minutes under shade. The fish were smoked with *Prosopis Africana*, *Anogerssus leiocarpus* and *Guinea senegalesis* fuel woods.

Preparation of Media

The sample was weighed each at 1g and put in a 9ml of normal saline and incubated. 0.1ml of the sample was taken and incubated using 10 folds of serial dilution. After dropping 0.1ml in the plate, it was kept in the plate for 2 hours and incubated for 4 hours as described by Anupama S. (2022).

Microbiological Analysis

The bacterial count was determined using nutrient agar method as described by Collins and Lyne (1970). The media was incubated at 31°C for 24-48 hours. The fungi were cultured in sabour and dextrose agar and the bacteria were cultured using MacConkey agar and Nutrient agar. The bacterial isolate were identified based on colony morphology.

Isolation and Identification of Colonies

The samples were inoculated in Nutrient medium and incubated at 39°C for 48 hours. In MacConkey's agar and Nutrient agar, the samples were cultured from both mediums by streaking method and incubation at 35°C for 48 hours was done to isolate the colonies of the sample which were replicated three times. The colonies were counted and expressed in colony forming unit per ml (cfu/ml) and values were estimated by means of duplicate determination. The isolated colonies were streaked on nutrient agar and pure cultures of the bacterial isolates were subjected to various morphological and biochemical characterization tests (Cheesbrough, 2006) to determine the identity of the bacteria isolates with reference to Bergey's Manual of Determinative Bacteriology (Buchanan and Gibbons, 1974).

Data Analysis

One-way ANOVA was used to determine the difference among treatment means at probability level of $\alpha=0.05$

Results and Discussion

The results of bacteria count of *Clarias gariepinus* smoked with different fuel wood types are as shown in Table 1.

The total bacteria count was highest in *Guinea senegalesis* (12×10^3 cfu/ml) and lowest in *Anogeissus leiocarpus* (5×10^3 cfu/ml). Sample treated with *Prosopis africana* showed a degree of microbial infestation of 8×10^3 cfu/ml, sample treated with *Guinea senegalesis* has 12×10^3 cfu/ml while the sample treated with *Anogeissus leiocarpus* has 5×10^3 cfu/ml.

Table 1: Total bacterial count of *Clarias gariepinus* smoked with *Prosopis africana*, *Guinea senegalesis* and *Anogeissus leiocarpus* fuel woods.

Fuel wood	Total bacterial load (cfu/ml)
<i>Prosopis Africana</i>	8×10^3 a
<i>Guinea Senegalese</i>	12×10^3 a
<i>Anogeissus leiocarpus</i>	5×10^3 a

Results of organoleptic assessment of *Clarias gariepinus* smoked with three (3) different wood types are as presented in Tables 2, 3 and 4 respectively, Table 2 revealed that samples have a total sum of square (TSS) as 1033.0, total degree of freedom of 27, mean square 4.2, F-ratio calculated 0.002, F-ratio tabulated 3.182 and sum of square 0.4. The analysis was done at $\alpha=0.05$ level of probability.

Table 2: Organoleptic assessment of *Clarias gariepinus* smoked with *Prosopis africana* fuel wood

Source of variation	Sum of squares (tss)	Df	Mean square	f-ratio calculated	f-ratio tabulated	S ²
Treatment	0.4	3	0.1	0.002	3.182	43.73
Error	1032.6	24	4			
Total	1033.0	27	4.2			

Table 3 shows organoleptic assessment of *Clarias gariepinus* treated with *Guinea senegalese* fuel wood types at $\alpha=0.05$ level of probability.

Table 3: Organoleptic assessment of *Clarias gariepinus* smoked with *Guinea senegalese* fuel wood.

Source of variation	Sum of squares (sst)	Df	Mean square	F-ratio calculated	F-ratio tabulated	S ²
Treatment error	0	3	0	0	3.182	0
	1123	24	46.79			
Total	1123	27	46.79			

Table 4 Shows organoleptic assessment of fish samples smoked with *Anogeissus leiocarpus* which revealed the following: the sum of square Error 1123, degree of freedom 3, sum of error in degree of freedom 24, total degree of freedom 27, sum of square error 46.79, total sum of square 0, F-ratio at 6.

Table 4: Organoleptic assessment of *Clarias gariepinus* smoked with *Anogeissus leiocarpus* fuel wood.

Source of variation	Sum of squares (sst)	Df	Mean square	F-ratio calculated	F-ratio tabulated
Treatment	0	3	0	0	3.182
Error	1388	24	57.83		
Total	1288	27			

$\alpha = 0.05$

Result of the study shows that there are bacteria load in all samples after storage of 8 weeks; the sample smoked with *Gunea senegalese* recorded the highest bacterial load colony forming unit of (12×10^3 cfu/ml), *Prosobis africana* has a high number of colony forming unit of bacteria (8×10^3 cfu/ml), while sample smoked with *Anogeissus leiocarpus* has the lowest microbial load with a colony forming unit of 5×10^3 cfu/ml. This indicates that *Anogeissus leiocarpus* probably has some anti-microbial properties that helped in reducing the bacterial load to a lowest level, even though it is not the best for human consumption. Ikutegbe and Sikoki (2014) stated that presence of colony forming unit of bacteria in food (Fish) or water even at the barest minimum is not accepted because it causes harm to human health.

Fish sample smoked with *Prosobis africana* had excellent texture with a mean value of 0.405 ± 0.01 , fish smoked with *Gunea senegalese* showed a mean value of 0.38 ± 0.03 while sample smoked with *Anogeissus leiocarpus* showed a mean value of 0.31 ± 0.01 .

Influence of wood types on fish sample showed that fish smoked with *Prosobis africana* has excellent taste and the fish smoked with *Gunea senegalesis* has the lowest taste quality.

This study showed that sample of *Clarias gariepinus* smoked with *Prosobis africana* have an excellent aroma (Odour) while fish smoked with *Gunea senegalesis* has the lowest aroma. *Prosobis africana* can best be used in fish smoking to enhance smell which will in turn attract consumers.

This study also indicates that sample smoked with *Prosobis africana* has an excellent appearance followed by sample smoked with *Anogeissus leiocarpus* and the least is sample smoked with *Gunea senegalesis*. This result is in agreement with Clucas and Ward (2016) who opined that handling process, fuel wood used and decreased moisture content are some of the factors that enhance texture, aroma (Odour), appearance and taste.

On storage stability (shelf life), sample smoked with *Anogeissus leiocarpus* tend to increase the storage time of sample because microbial load is less, aroma, appearance and texture are also good, followed by sample smoked with *Prosobis africana* and the least is sample smoked with *Guinea senegalese* which showed high microbial load that can cause spoilage to fish in a short possible time.

CONCLUSION

This study showed that samples smoked with *Prosobis africana* has the highest tendency to enhance texture, taste and appearance followed by *Anogeissus leiocarpus* and the least is *Guinea senegalese*. However, *Anogeissus leiocarpus* has the highest possibilities of increasing aroma (Odour) followed by *Prosobis africana* while *Guinea senegalesis* is the least in term of adding aroma to the smoked sample. *Prosobis africana* can best be used in fish smoking to enhance smell which will in turn attract consumers.

RECOMMENDATION

Further work should be carried out on the chemical composition of these fuel wood types to determine their constituent in the smoked sample.

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PROTECTIVE POTENTIAL OF CASHEW (*ANACARDIUM OCCIDENTALE*) NUT OIL AGAINST LARVAE OF THE HIDE BEETLE (*DERMESTES MACULATUS*) ON APPLICATION TO SMOKE-DRIED *OREOCHROMIS NILOTICUS* AND *CLARIAS GARIEPINUS* IN KADUNA STATE, NIGERIA.

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ABSTRACT

The hide beetle (*Dermestes maculatus*) have been applauded for its forensic importance as well as in preparation/cleaning of bone specimens in museums. However, its aggressive eating habit of dried fish and meat has made it a qualitative and quantitative threat to these products in storage. The aim of this study therefore is to assess the efficacy of Cashew nut oil against *D. maculatus* larvae when applied on smoke-dried *Oreochromis niloticus* and *Clarias gariepinus*. Oil from processed Cashew nuts used in this study was obtained by n-hexane extraction using a Soxhlet apparatus. Five concentrations of the oil (0.003mLg⁻¹, 0.009mLg⁻¹, 0.027mLg⁻¹, 0.081mLg⁻¹ and 0.162mLg⁻¹) were used for the test following the outcome of a pilot study. Progressive increase in repellence of *D. maculatus* larvae on *O. niloticus* treated with increasing cashew nut oil concentration at 24hr exposure period (6.67 – 90%) was recorded. A similar trend was observed when smoked-dried *C. gariepinus* treated with the same nut oil were exposed to *D. maculatus* larvae (20 – 46.67%). Mortality of *D. maculatus* larvae was also concentration dependent as 0.003mLg⁻¹ registered the least death (1.67% and 8.33%) while 0.162mLg⁻¹ resulted in 86.67% and 65% mortality of *D. maculatus* larvae exposed to treated *O. niloticus* and *C. gariepinus* respectively. The LC₅₀ of the oil against *D. maculatus* larvae was calculated to be 0.035mLg⁻¹ on *O. niloticus* and 0.055mLg⁻¹ on *C. gariepinus* implying the oil was most effective when applied on *O. niloticus* than on *C. gariepinus*. Fish processors and dried fish sellers can therefore utilize this result to more efficiently target all larval stages of *D. maculatus* with specifically high concentrations of the nut oil utilized in this study.

Keywords: *Cashew nut oil, Fishes, Dermestes, Mortality, Repellency*

1.0 INTRODUCTION

Cashew (*Anacardium occidentale* L.), a nut-producing evergreen tree crop, indigenous to Brazil, is currently being produced in over twenty-five states of the Nigerian federation for its nuts, apple and wood (Madou *et al.*, 2020). It's nut ranked fifth in volume of agricultural crop products Nigeria exports (Adesanya *et al.*, 2021). The nuts of cashew are consumed as snacks, processed to obtain oil or transformed into products like cashew butter (UNCTAD, 2021). Several beetles have been identified as threats to agricultural products both in the field and in storage. The shelf-life of these products have been shortened by the feeding action of these beetles (Akpotu *et al.*, 2021). Fish processed to dryness have been reported to be an excellent breeding ground both for Dermestids and *Necrobia rufipes*.

In the tropics, losses up to 30% of stored dried fish attributed to insect pest infestation, particularly hide beetle, have been reported (Flowra *et al.*, 2013). In Bangladesh, *D. maculatus* and *N. rufipes* are responsible for dried fish deterioration in storage, during transportation and at marketing stages, eating away the fish muscles practically to skeletons when fish is stored for long duration resulting in both quantitative and qualitative losses (Hossain *et al.*, 2016). Dermestids have equally been implicated in causing considerable economic losses in smoke dried fishes in Nigeria (Babarinde *et al.*, 2012). Pest infestation of dried fish creates room for opportunistic bacterial growth and higher levels of uric acid from their faeces, culminating in increased product deterioration with resultant off-stench and off-taste, unacceptable to both consumers and traders alike (Ghaly *et al.*, 2010). Therefore, the objective of this study is to determine the protective potential of cashew nut oil against *Dermestes maculatus* larvae on treated *Oreochromis niloticus* and *Clarias gariepinus*.

Materials and Methods

Source and Processing of Cashew nuts

The nut oil of Cashew (*A. occidentale*) used for this study was obtained from nuts collected from fruiting trees within the Samaru Main Campus of Ahmadu Bello University, Zaria. The Cashew plant was properly identified and authenticated at the Herbarium unit, Department of Botany, Ahmadu Bello University, Zaria, prior to processing. The nuts were removed from their respective pods, sun-dried for 10 days and pulverized in a mortar using pestle. The pulverized nuts was stored in pre – labeled new cellophane bags. Soxhlet extraction method was employed in extracting the oil from the nuts using n-hexane as solvent at 60 - 80°C.

Culturing of *Dermestes maculatus*

Insects belonging to *D. maculatus* taxon were obtained from infested fish purchased from Sabon – Gari market (11°13'N and 07°52'E), Zaria. They were properly identified using the pictorial keys of Haines (1991) at the Parasitology and Entomology laboratory, Department of Zoology, Ahmadu Bello University Zaria. Culture of larval generations used for the bioassay was as described by Lambkin and Khatoon (1990) and Hasan and Phillips (2010).

Source and Processing of Fish

A hundred and forty Fresh *Clarias gariepinus* and *Oreochromis niloticus* weighing over 20g each were purchased from fishermen at Zaria Dam by Jos road, Zaria, Kaduna State. They were properly identified using the keys of Kimsey and Fisk (1960).

Pilot Study

Range finding test was conducted by applying five nominal volumes (3-243mLkg⁻¹) to determine the concentration range of the oil to be used for the definitive tests (bioassay) following the method described by OECD (1992).

Repellency and Larvicidal Tests

The repellency and larvicidal tests were done in line with the method described by Akinwumi *et al.* (2007).

Data Analysis

All repellent and mortality data were subjected to Analysis of Variance (ANOVA) at $p \leq 0.05$ to determine significant difference between treatments. Tukey's Honesty Significant difference Test was employed for mean separation. Mortality data were subjected to Probit Analysis to determine their median lethal concentration (LC_{50}) of the nut oil.

Results and Discussion

Table 1 shows that at highest concentration (0.162mlg^{-1}), *A. occidentale* nut oil had the strongest repellent effect (46.67%) on the larvae of *D. maculatus* when applied on the surface of smoke-dried *C. gariepinus*, while 0.003mLg^{-1} posed the least repellent effect. The same nut oil applied on the surface of smoke-dried *O. niloticus* had the strongest repellent effect (90%) at the highest concentration applied (0.162mlg^{-1}). The repellent effect in both cases increased progressively with increase in concentration against the larvae of *D. maculatus*. There was no significant difference ($p \leq 0.05$) between the repellent effects of the oil to the insect in both fish species, however between concentrations in both cases the differences were significant ($p \leq 0.05$). There was significant increase ($p \leq 0.05$) in mortality of larvae as the time increased from the first 24 hours to 96 hours exposure period, as concentration of the oil of *A. occidentale* increased from 0.003 to 0.162mLg^{-1} (Tables 1 and 2). The cashew nut oil was more effective in killing the larvae of *D. maculatus* at 24hrs on *O. niloticus* (15, 55 and 86.67%) in comparison to *C. gariepinus* (11.67, 40 and 65%) corresponding to 0.027 , 0.081 and 0.162mLg^{-1} of the cashew nut oil. At 72 and 96hrs, there was noticeable increase in larval mortality on both fish species from 0.027 - 0.162mLg^{-1} of the oil. *C. gariepinus* had 11.67-78.33% while *O. niloticus* had 6.67-100% corresponding to the oil concentration. This implies that cashew nut oil was more effective in protecting *O. niloticus* in comparison to *C. gariepinus* against the larvae of *D. maculatus* in 96hrs. The nut oil of *A. occidentale* was most effective against the larvae of *D. maculatus* on *O. niloticus* with LC_{50} value of 0.035mLg^{-1} which was lower in comparison to that of the same oil against the larvae when applied on smoke-dried *C. gariepinus* (0.055mLg^{-1}).

Table 1: Toxicity of applied Cashew nut oil on *O. niloticus* and against *Dermestes maculatus* larvae

Fish Species	Dose of cashew nut oil (mLg^{-1})	Larval Mortality (%)				24hr Repellency (%)	96hr LC_{50} (mLg^{-1})	Regression equation
		24hr	48hr	72hr	96hr			
	Control	0	0	0	0	0		
<i>O. niloticus</i>	0.003	0	0	0	0	0	0.035	$y = 3.6802x - 0.6684$
	0.009	1.67	1.67	6.67	6.67	0		
	0.027	15	15	18.33	21.67	6.67		
	0.081	55	61.67	70	80	73.33		
	0.162	86.67	93.33	100	100	90		

Table 2: Toxicity of applied Cashew nut oil on *C. gariepinus* against *Dermestes maculatus* larvae

Fish Species	Dose of cashew nut oil (mLg ⁻¹)	Larval Mortality (%)				24hr Repellency (%)	96hr LC ₅₀ (mLg ⁻¹)	Regression equation
		24hr	48hr	72hr	96hr			
	Control	0	0	0	0	0		
<i>C. gariepinus</i>	0.003	0	0	0	0	0	0.055	y = 2.9982x - 0.2066
	0.009	8.33	8.33	11.67	13.33	0		
	0.027	11.67	11.67	23.33	23.33	0		
	0.081	40	58.33	65	70	20		
	0.162	65	70	78.33	85	46.67		

The repellent effect of the nut oil of *A. occidentale* on the larvae of *D. maculatus* was significant. It repelled the larvae from treated smoke-dried *C. gariepinus* and *O. niloticus*, and the effect increased with increasing concentration of the oil. The oil may have masked the attractive odours in the fish, thereby blocking the gustatory receptors (olfactory receptors) in the larvae of *D. maculatus* (Verschut *et al.*, 2019). The oil may be sensed by an olfactory receptor that activates a neural circuit that elicits avoidance behavior by the larvae, that is it may be perceived as a noxious odour by the larvae of *D. maculatus* (Verschut *et al.*, 2019). Bellmann *et al.* (2010) reported that a repellent odorant at high concentration can also override the repulsive effect of strong illumination indicating that odor stimuli can interact with and influence the behavioral responses to visual stimuli in *Drosophila* larvae. They further stated that the larval olfactory system contains a designated neuronal pathway for repellent odorants; affirming that activation of a specific class of olfactory receptor neurons (ORNs) determines olfactory avoidance behaviour. Some active constituents in the oil such as monoterpenes, sesquiterpenes, β – caryophyllene, diterpenes alcohol (phytol), triterpenes and volatile terpenoids and the fatty acids may also be responsible for the repellent effect observed. Nerio *et al.* (2010) demonstrated that sesquiterpenoids were repellent to the German cockroach, *Blattella germanica* (Linnaeus). This is a pointer to the fact that chemical constituents of the oil of cashew nuts used in this study contains certain properties which is largely responsible for the repellent effect observed.

Nut oil of *A. occidentale* tested in this study caused mortality of *D. maculatus* larvae compared to the untreated control, which indicate the insecticidal potential of the oil for the control of insect pests of smoke-dried fish. The oil is suspected to have had a contact mode of action on the larvae since they were killed as a result of their transient contact with the treated fish. This oil may have induced the closure of the spiracles, resulting in asphyxiation and eventually death. Rotimi *et al.* (2011) reported that essential oils block respiratory siphon (asphyxiation) causing death in *Anopheles gambiae*. Lale (1995) also reported that plant extracts are highly lipophilic and could penetrate the cuticle of insects to block the spiracles, create neurotoxicity and eventual death. The toxic effect of the nut oil observed in this study could also be attributed to the various chemical ingredients like terpenoids and triterpenes present along side the fatty acid compositions in the oil. The inability of the larvae of *D. maculatus* to detoxify the toxins in the oil when actively feeding on the treated fish may also be responsible for their death. Toxicity of essential oils is associated with the presence of many chemical ingredients such as triterpenoids which may cause symptoms that suggest a neurotoxic mode of action, and that cases of high mortality occur in larvae partly because of

their inability to detoxify plant toxins when feeding actively, especially at the 1st to 4th instar larval stages (Lu and Wu, 2010 and Chaubey, 2011).

CONCLUSIONS

This study revealed that cashew nut oil was potent both as a repellent and larvicide against the larvae of *D. maculatus* implicating 0.081mLg⁻¹ and 0.162mLg⁻¹ doses as the most effective. The efficacy of the nut oil was attributed to the presence of active ingredients in the oil. Cashew nut oil (0.081mLg⁻¹ and 0.162mLg⁻¹) doses are therefore recommended to both fish traders and fisher folks for effective prevention and control of *D. maculatus* infestation of smoke-dried *O. niloticus* and *C. gariepinus*.

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CHARACTERIZATION OF POLYCYCLIC AROMATIC HYDROCARBONS CONCENTRATIONS IN SILVER CATFISH (*BAGRUS BAYAD*) SMOKED WITH DIFFERENT WOODTYPES

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ABSTRACT

The study examines the effects of different wood types commonly used amongst fish processors in the study area. Neem tree (*Azadirachta indica*), Jackalberry tree (*Diospyros mespiliformis*), Kinkeliba tree (*Combretum micranthum*), Purple Orchid tree (*Piliostigma reticulatum*) and Charcoal are among the wood types. A total of 125 Silver catfish (*Bagrus bayad*) were purchased, gutted and then divided into 5 groups (A to E) of 3 Kg each and each group was assigned to a specific wood type. Smoking kilns made from perforated metal drums were used. Traditional smoking results in high Polycyclic Aromatic Hydrocarbons (PAH) contents in contrast to modern studies that use special modern equipment to smoke fish at lower temperature to obtain a lower concentration of PAH. Eighteen PAH concentrations were obtained and the results shows values that vary greatly differ between wood types. The total mean for benzo(a)pyrene ranged from 0.36 mg Kg⁻¹ to 1.42 mg Kg⁻¹ exceeding EU recommended threshold of 0.01 mg Kg⁻¹ g. The overall mean PAH4 index score was lowest in group C (1.78mg kg⁻¹) and highest in groups E (7.49mg Kg⁻¹) both of which were greater than the recommended EU value of 0.03mg Kg⁻¹. Findings from the study demonstrated that wood D (*Piliostigma reticulatum*) contains the least amount of total PAHs of all the wood types used and can be encouraged among local fish processors, protecting both consumers and processor from exposure.

Keywords; Polycyclic Aromatic Hydrocarbons (PAHs), wood types, Silver catfish, Drum kiln.

Introduction

Silver catfish *Bagrus bayad* belongs to the Bagridae family and accounts for a large portion of commercial catches in Nigerian fresh waters (Olanrewaju *et al.*, 2020). According to Sipaub - Tavares and Braga (1999), nature provides a wide range of organisms for human's consumption that vary in size and taxonomic group. However, in the tropics, fish is a perishable food material that deteriorates quickly after harvest due to high ambient temperature (Aberoumand, 2010); thus, due to lack of storage facilities, it requires immediate preservation after harvesting. Despite its importance, post-harvest losses from fish are substantial, ranging from 20 to 50 % of total catch, which has resulted to low income levels among those involved in the fish value chain (Adeyeye *et al.*, 2016). Fish, a reliable protein source are processed in a variety of ways to preserve its nutritional (physical and chemical) qualities, increase its economic value, and extend its shelf life as. Some of these methods of preservation include drying, frying, canning, salting, smoking etcetera (Ubwa *et al.*, 2015).

Smoking, one of the method of processing allows fish to be stable during storage, increases their appeal and provides special aroma to smoked products all due to smoke's inactivating effect on enzymes and microorganisms present in the fish muscle (Nnaji and Ekwe, 2018). However, fish may become contaminated if the procedure is not well regulated (Gomez-Estaca *et al.*, 2011).

Purcaro *et al.* (2013) stated that smoke is the end product of thermal decomposition of wood when oxygen is limited. Romeo (2008) identified over 400 chemicals in wood smoke, including; 40 acids, 22 alcohols, 131 carbonyls, 22 esters, 46 furans, 16 lactones, and 75 phenols, the origin of which has been documented to be polymers in the wood, are also present in wood smoke. In addition to these substances, wood smoke contains a mixture of antioxidants, antimicrobials, and potentially hazardous substances, such as Polycyclic Aromatic Hydrocarbons (PAHs) (Lingbeck *et al.*, 2014). PAHs are potential health risk that occurs during smoking, and they frequently appear as a complicated combination of various compounds (Purcaro *et al.*,

2013). According to Wretling, *et al.* (2010), smoke particles contain PAHs and can contaminate food product during smoking process. Studies on several charcoal-smoked foods have found PAHs, such as benzo[a]pyrene, anthracene, chrysene, benzo[a]anthracene, and indeno[1,2,3-c,d] pyrene, most of which have been found to be carcinogenic in nature (Amos-Tautua *et al.*, 2013). Their concentrations in smoked fish of depend on a variety of factors, including the smoking process, the smoke source, the temperature of the combustion, and the intensity of the heat (Garcia-Falcon and Simal, 2005). According to Nnaji and Ekwe (2018), 16 PAHs have been designated as priority PAHs because they are thought to be more harmful to humans than the other PAHs. Almost 70 % of PAHs are consumed in foods, including smoked fish. Furthermore, wood's carcinogenic activity may be harmful to fish processors (Abraha *et al.*, 2018).

The four most commonly used types of wood in Katsina State, according to Dauda *et al.* (2020), were used as a source of smoke. Wood species used include *Azadirachta indica* (Neem tree), *Diospyros mespiliformis* (Jackalberry tree), *Combretum micranthum* (Kinkeliba tree), and *Piliostigma reticulatum* (Purple Orchid tree). Neem tree is known locally as 'Darbejia' or 'Bedi'; Jackalberry tree as 'Kanya'; Kinkeliba tree as 'Geza'; Purple Orchid tree as 'kalgo'; these trees serve many purposes including firewood, natural fertilizer and insecticides, preparation of local alimentary paste, medicinal aesthetics purposes, treatment of diarrhea (Tandon & Sirohi, 2010; Orwa *et al.*, 2009; Yelemou *et al.*, 2007; Verkerk & Wright, 1993; Vogt, 1995; Akerele, 1991). Therefore, the objective of the current study is to compare and assess how different wood types affect the levels of polycyclic aromatic hydrocarbons (PAHs) in the smoked product (*Bagrus bayad*) which is naturally abundant in the study area in metal drum kilns.

Materials and Methods

Sample Collection and Preparation

A total of 125 freshwater silver catfish (length range of 15 – 26 cm) were purchased from Garhi landing site of Zobe Reservoir in Dutsin-Ma Local Government Area of Katsina State. The fish were transported chilled on ice to the Federal University Dutsin-Ma Fish market for preparation and Smoking. The fish were then divided into five groups of 3 Kg each, with each group assigned to a particular wood type.

The fish were gutted and thoroughly washed before being immersed in a 5% brine solution for 15 minutes, drained, and air dried for an hour before smoking. Fish tails were slatted by making a small incision in them, and the fish was coiled into a horse shoe shape by securing the tail inside the mouth with clean wooden skewers.

Smoke Source and Smoking Process

The wood species used were sourced from the wednesday market in the study area and these are; *Azadirachta indica* (Neem tree), *Diospyros mespiliformis* (Jackalberry tree), *Combretum micranthum* (Kinkeliba tree), *Piliostigma reticulatum* (Purple Orchid tree) and Charcoal (commercial).

The smoking took place at the University Fish Market in Dutsin-Ma Local Government Area. Five modified metal drum kilns were used for the smoking process. They were built using slightly modified methods described by Idah and Nwankwo (2013).

Before smoking, a 26kg average weight of each of the woods was placed in the combustion chamber of each kiln and ignited. The fire was lit for about 20 minutes before the fish were introduced. To ensure that the fish were thoroughly smoked and dried, they were first subjected to direct hot smoking for the first hour and then to a lower temperature for 6 to 8 hours by constantly adjusting the burning wood to regulate the heat and avoid charring. Fish were occasionally turned to ensure consistent smoking. After smoking, the fish were removed from the kiln and allowed to cool at room temperature for about one hour, before being packed into perforated cardboard box. The fish were smoked for a period of 8 to 10 hours.

Analysis of PAHs

The extraction of PAHs from the samples was based on the solid-liquid extraction procedure described by (Ubwa *et al.*, 2012). While the analysis was carried out using the GC/MS method as described by (Nnaji and Ekwe, 2018) using an Agilent 7890 Gas Chromatograph outfitted with an auto sampler and connected to an Agilent 5975 Mass Spectrometric Detector (MSD).

Results and Discussion

Table 1 shows the eighteen (18) PAHs detected in varying concentrations among the treatments, which were found to be significantly different.

In this study, the mean score for benzo(a)pyrene was 0.88 mg Kg⁻¹ for sample A, 0.81 mg Kg⁻¹ for sample B, and 0.36 mg Kg⁻¹ for sample C, whereas it was 0.58 mg Kg⁻¹ and 1.42 mg Kg⁻¹ for sample D. The amount of Benzo(a)pyrene in the various types of wood varied greatly, but they were all above the recommended EU levels.

In the United Kingdom as at 2016, the global acceptable range for benzo(a)pyrene is 0.0812 mg Kg⁻¹ (FAO, 2019).

Benzo(a)pyrene, a highly carcinogenic substance, has gotten a lot of attention around the world. The substance is used as a marker to determine the amount of carcinogenic material in food (FAO, 2019). Importation of smoked fish in excess of the recommended limit of PAHs were rejected from African countries according to FAO (2019) statistics.

Mihalca *et al.* (2011) found that the EU maximum amount of benzo(a)pyrene in smoked products, including smoked fish and smoked fish products, is 0.01mg Kg⁻¹; however, our findings are in line with Tongo *et al.* (2017) and Amos-Tautua *et al.* (2013), who found that most processors use wood logs to quickly smoke fish with little or no knowledge of the hazardous consequences of these chemicals.

Table 1. Total mean Concentrations Polycyclic Aromatic Hydrocarbons (PAHs) detected.

SN	PAHs	A (mg Kg ⁻¹)	B (mg Kg ⁻¹)	C (mg Kg ⁻¹)	D(mg Kg ⁻¹)	E (mg Kg ⁻¹)
1	Naphthalene	1.09±0.02	3.14±0.03	2.09±0.02	1.01±0.02	N.D
2	Benzen1,2,3-trimethyl	6.13±0.03	4.11±0.10	4.64±0.13	0.29±0.01	1.47±0.26
3	2Methylnaphthalene	0.97±0.03	1.02±0.02	2.76±0.01	0.98±0.1	N.D
4	Acenaphthylene	0.83±0.03	0.96±0.03	2.28±0.01	0.80±0.01	N.D
5	Acenaphthene	0.63±0.03	0.98±0.02	1.08±0.03	0.31±0.01	N.D
6	Fluorene	0.94±0.02	1.11±0.01	0.73±0.56	0.11±0.02	N.D
7	Anthracene	0.88±0.01	1.40±0.01	0.46±0.01	0.88±0.59	1.56±0.02
8	Phenanthrene	0.99±0.01	1.12±0.01	0.40±0.01	0.32±0.02	1.30±0.03
9	Fluoranthene	0.91±0.03	0.87±0.02	0.38±0.02	0.33±0.06	1.82±0.02
10	Pyrene	0.98±0.01	0.96±0.02	0.51±0.01	0.92±0.02	1.09±0.03
11	Benzo(v)fluoranthene	0.74±0.02	0.83±0.02	0.47±0.01	0.42±0.02	0.56±0.02
12	Dibenzo(a,h)anthracene	0.57±0.01	0.86±0.04	0.47±0.02	1.22±0.02	N.D
13	Indeno(1,2,3-cd)pyrene	1.10±0.01	0.72±0.02	0.30±0.02	0.34±0.03	N.D
14	Benzo(g,i,h)perylene	1.24±0.31	0.81±0.03	0.52±0.02	0.61±0.01	N.D
		19.00	18.89	17.09	8.60	7.80
	PAH4 index					
15	Benzo(a)anthracene	0.98±0.01	0.43±0.03	0.49±0.01	0.94±0.02	1.75±0.57
16	Chrysene	0.84±0.01	0.37±0.03	0.32±0.02	0.38±0.02	1.14±0.01
17	Benzo(b)fluoranthene	0.97±0.02	1.79±0.02	0.61±0.01	0.64±0.01	3.18±0.02
18	Benzo(a)pyrene	0.88±0.02	0.81±0.02	0.36±0.01	0.58±0.02	1.42±0.02
		3.67	3.40	1.78	2.54	7.49
	TOTAL	21.67	22.29	18.87	11.14	15.29

A= *Azadirachta indica*, B= *Diospyros mespiliformis*, C= *Combretum micranthum*, D= *Piliostigma reticulatum*,

E= Charcoal and N.D= Not Detected, Mean±SD P>0.05 Significant level

The PAH4 index includes four chemicals: chrysene, benzo(a)anthracene, benzo(b)fluoranthene, and benzo(a)pyrene, which are used to assess the toxicity of PAHs. The permitted PAH4 total values were calculated by adding these hydrocarbons together. Acceptable values include 0.51 mg Kg⁻¹ in the United Kingdom and 0.10 mg Kg⁻¹ in Germany in 2016 while 0.05 mg Kg⁻¹ in Belgium in 2014 (FAO, 2019). However, the EU only recommends 0.03 mg Kg⁻¹ (Tongo *et al.*, 2017). According to the findings of this study, the four wood types (A-D) recorded a high value ranging between 1.78 and 3.67 mg Kg⁻¹ g, while charcoal, used as a control, had the highest concentration of 7.49 mg kg⁻¹. The values recorded are significantly higher than those recommended by the EU. The total PAH4 results are higher than the values

recorded in works by (Mirja *et al.*, 2018), with a value of 0.004mg Kg⁻¹ far less than the recommended value, which could be attributed to the distance between the fire and the smoked product (approximately 5m). According to Garcia-Falcon and Simal (2005), one of the crucial factors affecting PAH concentration is the distance between the smoke source and the food. The results outperformed previous studies, particularly those of (Nnaji and Ekwe, 2018), who found a value of 0.05mg Kg⁻¹ for Catfish and 0.012mg Kg⁻¹ for Tilapia when temperature was controlled. The current study agrees with FAO (2019) reports that conventional kilns, specifically drum kilns, do not smoke PAH-free fish products.

Total PAH concentrations varied across all woods, with type A having the highest level at 21.67 mg Kg⁻¹ and type D having the lowest level at 11.14 mg Kg⁻¹. The values are noticeably different because different kinds of wood emit different amounts of smoke. The 15.29mg Kg⁻¹ value obtained was higher than type D even though charcoal produces less smoke than other types of wood. Additionally, the amount of PAHs in the wood may vary depending on the chemical makeup of the wood (cellulose, hemicelluloses, and moisture content). According to Disner *et al.* (2017), the values of naphthalene, which can cause acute onset of dark urine and watery diarrhea among other forms of toxicity after consumption, ranged between 1.01 and 3.14 mg Kg⁻¹ in the current study (Wood types A to D) which is less than that of (Nnaji and Ekwe, 2018), who detected higher (68.96mg kg⁻¹) amounts of Naphthalene.

On the other hand, traditional wood smoking has no set procedure; as a result, various outcomes with high levels of PAHs above the advised limits may be obtained. This study was able to obtain lower PAH concentrations than more recent studies like (Oz, 2020), which smoked fish at low temperatures using specialized modern equipment.

CONCLUSION

The results shows that the woods used in this experiment differ significantly from each other with respect to the total Benzo(a)pyrene, PAH4 and PAHs content. Purple Orchid tree (*Piliostigma reticulatum*) (wood type D) exhibited a lower PAH concentration implying that lower concentrations could be achieved with further improvements to the smoking kiln design.

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ESTIMATE OF FUNGAL AND CHEMICAL COMPOSITION OF SMOKED *Clarias gariepinus* (Burchell, 1822) SOLD IN TELLA AND MAYO-RENEWO FISH MARKET, GASSOL, TARABA STATE, NIGERIA

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ABSTRACT

African catfish, *Clarias gariepinus* is a widely acceptable animal protein because of its high palatability and nutritional importance. However, the wholesomeness and nutritional composition of fish the can be affected by spoilage caused through poor handling, processing and preservation. Therefore, this study assessed some quality parameters of smoked *Clarias gariepinus*.

The analyses were conducted on fish samples (n = 60) collected from Tella and Mayo-Renewo open fish markets in Taraba State, and transferred to the laboratory. Two portions with one gram (1g) from each sample were aseptically collected to assess the fungi load using slide culture techniques and the proximate composition, caloric value, trimethylamine (TMA), free fatty acid (FFA), and peroxide levels using standard biochemical methods. The normality of distribution and homogeneity of variances of the data were carried out, followed by independent t-test at 5% level of significance, with the aid of statistical package for social sciences (SPSS version 25).

The result of the study showed the identified fungi (CFU/g) significantly ($P < 0.05$) present in the smoked fish samples as: *Aspergillus sp* (Tella $5.80 \times 10^3 \pm 3.33$: Mayo-Renewo $6.13 \times 10^3 \pm 33.33$), *Alternaria sp* (Tella $2.50 \times 10^3 \pm 0.00$: Mayo-Renewo $2.80 \times 10^3 \pm 0.00$), *Brachiomyces sp* (Tella $6.50 \times 10^3 \pm 0.00$: Mayo-Renewo $5.80 \times 10^3 \pm 0.00$), *Penicillium sp* (Tella $1.90 \times 10^3 \pm 0.00$: Mayo-Renewo $2.23 \times 10^3 \pm 33.33$). The proximate composition of the samples were not significant at $P < 0.05$; however, crude protein (CP, %) values were lesser in Tella (61.69 ± 0.94), than Mayo-Renewo (62.66 ± 1.45). The caloric value was higher in Tella (81.23 ± 0.07), than Mayo-Renewo (76.95 ± 0.00). The TMA (mg/100g), FFA (%), Peroxide (meq/kg), and caloric values (Kcal/100g) were significantly different ($p < 0.05$) in all the samples, as TMA was lesser in Tella (18.01 ± 0.01), than Mayo-Renewo (21.23 ± 0.00). The FFA was higher in Tella (5.75 ± 0.00), than Mayo-Renewo (3.45 ± 0.00), and Peroxide value was higher in Tella (22.97 ± 0.00), than Mayo-Renewo (19.45 ± 0.00).

Fungal infestation in smoked *Clarias gariepinus* were mostly higher in Mayo-Renewo fish market, however biochemical spoilage on the smoked fish samples were higher in Tella fish market, with also the least % CP. This therefore, showed the need for improved approach for post-harvest handling, processing and preservation of *Clarias gariepinus* in Tella and Mayo-Renawo fish markets.

Key words: *Clarias gariepinus*, nutritional composition, fungal infestation, Trimethylamine, Free Fatty Acid, Peroxide

INTRODUCTION

Fish is an important foodstuff, especially in developing countries due to its high protein content, nutritional values, and rich bioavailability of vitamins and minerals for both young and old consumers (Koffi-Nevry *et al.*, 2011). The consumption of fish has been identified by several studies to have health benefits such as reduced risk of coronary heart disease, cancers and inflammatory diseases (Marchioli, 2001; Arannilewa *et al.*, 2005; Surtharshiny and Sivashanthini, 2011). It is an affordable and highly palatable source of animal protein that is widely acceptable and accessible by low income earning households in urban areas (Bene and Heck, 2005; Eyo, 2001).

Different processing methods such as salting, boiling, frying, sun drying, roasting and smoking have been used to preserve, maintain or increase the bioavailability of nutrients (Olayemi *et al.*, 2011; Saliu, 2008). But, fish being a highly perishable food commodity, could still have some challenges in preservation, especially in the tropics due to the little or unavailability of modern processing technologies. However, smoke drying of fish is a preservation method that seems predominantly practice in Nigeria. Smoking has the advantage of giving the processed fish product a better aroma, and taste with the concentration of nutrients (Ogunbambo and Osibona, 2012). It combines three effects of preservation, drying and cooking of fish. Despite processing, there still exist some microorganisms that thrive on the smoked fish from the retail outlets (Tesfay and Teferi, 2017). This portends serious health hazard for consumers due to the microbial loads and the subsequent biochemical changes on the fish that results in the depletion of the nutritional contents and also bioaccumulation of poisonous compounds in the fish.

Good storage practices are not observed by most wholesalers of smoked fish, as reports shows that smoke-dried fish are often contaminated with microorganisms such as bacteria, yeasts and moulds from the processing units to market centers (Sani *et al.*, 2016). For these reasons, the need for regularly determination of nutritional status of fish is necessary to ensure that they are within the ranges of dietary requirement and commercial specifications, since food safety is a shared responsibility of all the stakeholders along the food chain (Watchman, 2000). Therefore, this study aimed at investigating the nutrient status, fungal, and biochemical spoilage levels associated with smoked *Clarias gariepinus* sold in Tella and Mayo-renewo, open fish markets at Gassol, Taraba State, Nigeria.

MATERIALS AND METHODS

Sample collection

Ten (10) samples of *Clarias gariepinus* were collected at one-month intervals (January - March) from Tella and Mayo-Renewo open fish markets in Gassol Local Government Area, Taraba State, and subsequently analysed.

Sample analysis

The samples were divided into two batches for fungal and proximate analyses, and caloric value, trimethylamine, free fatty acid, and peroxide estimations.

Fungal analysis

Two (2) grams of samples were each weighed with the aid of a sensitive scale (ATOM – 110C platinum) for fungal identification using slide culture techniques (vLab.amrita.edu. 2011). Briefly, Sabouraud agar supplemented with aureomycin was prepared aseptically, cut into a block of 5mm and inoculated with the prepared fish sample. After which a sterile cover glass was placed on the upper surface of the blocked agar, and incubated at room temperature for 48 hours. The cover slip was removed from the agar block and place on another slide, to which a drop of the dye lactophenol cotton blue was added, and observed for microscopic structures.

Trimethylamine analysis

One (1) gram of the samples were each dropped into 2mL vial containing 0.5mL of 1:4 v/v solution of 1.0 N NaOH, followed by addition of methanol to neutralize the sample, then sealed and shaken briefly to mix well before analysis. As described by Wekell (2022), the TMA was calculated as:

$$\text{Mass of analytes in sample} = \frac{\text{number of moles of analyte}}{\text{weight}}$$

Free fatty acid analysis

One (1) gram of the samples were each dropped into 250mL Erlenmeyer flask containing 50mL of chloroform. After 5 drops of m-cresol indicator was added, the solution was titrated to purple end-point with aqueous 0.05m NaOH. A blank titration was prepared. The free fatty acid was then calculated per gram of sample = $\frac{1000NV}{W}$, where N, V and W denoted the molarity of titrant, the volume (mL) of titrant, and weight (g) of samples respectively (Chakrabarty, 2003).

Peroxide analysis

Five (5) grams of the samples were used in a stopper flask and dissolved in 30mL of 3:2 v/v acetic acid chloroform, and saturated aqueous potassium iodide solution (0.05mL) was added. The mixture was shaken vigorously and titrated with 0.1m sodium thiosulfate solution with constant stirring until the yellow color almost disappeared, when a starch indicator solution (0.05m) was added. The thiosulfate solution was added drop wise until the blue color disappeared. A blank sample was analyzed similarly. The peroxide value was obtained from the formula below;

$$Pv = (s - b) \times m \times \frac{1000}{w}$$

Where: s = Titre of sample (mL), b = Titre of blank (mL),

m = Molarity of thiosulfate solution, w = Weight of sample (g) (William and Christie, 2012).

Proximate analysis

Samples of smoked dried catfish were grounded into fine particles and homogenized. Each homogenized samples were neatly packed into a sterile transparent container and appropriately labeled. The proximate composition of the processed fish samples were analysed according to the methods of the Association of Analytical Chemist (AOAC) (1990). After which, the percent (%) moisture and ash content, crude protein, fibre, fat, and carbohydrate content were calculated.

Caloric value analysis

The determination of caloric value was carried out as described by Laura (2019). Afterwards, the caloric value of the fish sample was calculated using the formula: $Q = mcp\Delta T$. Where: Q = heat absorbed by water, m = mass of water in grams, cp= 1cal/g °C, ΔT = change in temperature.

Data analysis

Data collected for fungal prevalence, proximate composition, caloric value, free fatty acid (FFA), trimethylamine, peroxide, from the two locations were evaluated for normality of data and constant variance, followed by independent sample t-test at 5% level of significance, with the aid of statistical package for social sciences (SPSS version 25).

RESULTS AND DISCUSSION

Fungal Infestation on Smoked *Clarias gariepinus*

The result for the fungal infestation on the smoked fish (*Clarias gariepinus*) sold in Tella and Mayo-Renowo market is as presented in table 1. The four fungi colonies identified in each of the markets were *Aspergillus sp*, *Alternaria sp*, *Brachiomycetes sp* and *penicillium sp* with the average coliform forming unit per gram (CFU/g) count of $5.57 \times 10^3 \pm 33.33$, $2.50 \times 10^3 \pm 0.00$, $6.50 \times 10^3 \pm 0.00$ and $1.90 \times 10^3 \pm 0.00$ respectively for Tella Market, and $6.13 \times 10^3 \pm 33.33$, $2.80 \times 10^3 \pm 0.00$, $5.80 \times 10^3 \pm 0.00$, and $2.23 \times 10^3 \pm 33.33$ respectively for Mayo-Renowo market. The mean count revealed that *Aspergillus Sp.* in Tella ($5.57 \times 10^3 \pm 33.33$) was significantly lesser than the observed count in Mayo-Renowo ($6.13 \times 10^3 \pm 33.33$). This was similar in the case of *Alternaria Sp.* with Tella ($2.50 \times 10^3 \pm 0.00$) lesser than Mayo-Renowo ($2.80 \times 10^3 \pm 0.00$). On the other hand, *Brachiomycetes Sp.* count for Tella ($6.50 \times 10^3 \pm 0.00$) was higher than Mayo-Renowo ($5.80 \times 10^3 \pm 0.00$) while *Penicillium Sp.* was significantly lesser in Tella ($1.90 \times 10^3 \pm 0.00$) than Mayo-Renowo ($2.23 \times 10^3 \pm 33.33$) market.

Table 1: Fungal Infestation of smoked *Clarias gariepinus* sampled in Tella and Mayo-Renowo

Locations	<i>Aspergillus sp.</i>	<i>Alternaria sp.</i>	<i>Brachiomycetes sp</i>	<i>Penicilliumsp</i>
Tella	$5.567 \times 10^3 \pm 33.33$	$2.50 \times 10^3 .00 \pm 0.00$	$6.50 \times 10^3 \pm 0.00$	$1.90 \times 10^3 \pm 0.00$
Mayo-Renowo	$6.13 \times 10^3 \pm 33.33$	$2.80 \times 10^3 \pm 0.00$	$5.80 \times 10^3 \pm 0.00$	$2.23 \times 10^3 \pm 33.33$
P-values	0.00	0.00	0.00	0.00

Chemical compounds (Free Fatty Acid, Trimethylamine, and Peroxide), and caloric values in the smoked *Clarias gariepinus* fish

The mean values of free fatty acid (FFA, %) in the sampled fish was higher in Tella (5.75 ± 0.003) than Mayo-Renowo (3.45 ± 0.03). However, the trimethylamine (mg/100 g) level in Tella (18.01 ± 0.007) was lesser than Mayo-Renowo (21.23 ± 0.003). The peroxide value (mg/100g) was higher in Tella (22.97 ± 0.003) than Mayo-Renowo (19.45 ± 0.003). This was the same for energy values (Kcal/100g), where Tella (81.23 ± 0.007) was higher than Mayo-Renowo (76.95 ± 0.000) as indicated in table 2.

Table 2: Free Fatty Acid, Trimethylamine, Peroxide, and Energy values of smoked *Clarias gariepinus* fish sampled in Tella and Mayo-Renowo

Locations	Trimethylamine (mg/100g)	FFA (%)	Peroxide (meq/kg)	Kcal/100g
Tella	18.01±0.01	5.75±0.00	22.97±0.00	81.233±0.007
Mayo-Renowo	21.23±0.00	3.45±0.00	19.45±0.00	76.950±0.000
P-values	0.00	0.00	0.00	0.00

Proximate composition of the smoked *Clarias gariepinus* sold in Tella and Mayo-Renowo market

The result for the proximate composition of the smoked *Clarias gariepinus* sold in Tella and Mayo-Renowo market revealed (Table 3) no significance difference ($p>0.05$). The CP (%) for smoked fish in Tella (61.69±0.94) was less than Mayo-Renowo (62.66±1.45). However, Ash content (%) In Tella was higher (6.82±1.45) higher (6.82±1.72) than Mayo-Renowo (6.77±1.49) while fibre content (%) in Tella were higher (5.66±1.65) the Mayo-Renowo (3.86±1.52), lipid content (%) was also higher in Tella (13.76±1.26) than Mayo-Renowo (12.19±0.84). The moisture content (%) in Tella is significantly less ($p<0.05$) less in Tella (7.17±0.94) compared to Mayo-Renowo (9.22±0.82). This was the same for nitrogen free extract content (%) (8.61±1.38) which was significantly ($p<0.05$) higher in Tella (8.61±1.38) than Mayo-Renowo (6.42±1.98), dry matter content (%) in Tella was significantly ($P<0.05$) higher (91.66±0.80) than Mayo-Renowo (90.56±0.90).

Table 3: Proximate composition of the smoked *Clarias gariepinus* sold in Tella and Mayo-Renowo

Locations	% CP	% Ash	% Fibre	% Lipid	% Moisture	NFE	DM
Tella	61.69±0.94	6.82±1.72	5.66±1.65	13.76±1.2	7.17±0.94	8.61±1.38	91.66±0.80
	4			6			
Mayo-Renowo	62.66±1.4	6.77±1.49	3.86±1.52	12.19±0.8	9.22±0.82	6.42±1.98	90.56±0.90
	5			4			
P-values	0.58	0.98	0.43	0.32	0.12	0.12	0.38

Fungi can grow and cause spoilage, such as rot and discoloration in smoked fish products. They can also alter the flavor and textural quality resulting in nutritional quality being depleted. The fungal load on smoked *Clarias gariepinus* recorded in this study when added together, were observed to be higher than the recommended $< 7.0 \log_{10}$ CFU/g by the Health protection Agency, (2009). However, with the exception of *Aspergillus sp* and *Branchiomyces sp.*, when observed as individually, they were within the maximum recommended fungal count for good quality fish product at $5.7 \log_{10}$ CFU/g as reported by International Commission on Microbiological Specifications (1986). The mean fungal count revealed that smoked *Clarias gariepinus* sold from Tella and Mayo-Renowo are contaminated by fungi, although the mean value of smoked *Clarias gariepinus* sold from Tella had higher value than that of Mayo-Renowo. This may be as a result of the poor handling and storage of the fish prior to marketing. Therefore, education and awareness campaign among handlers and sellers on proper hygiene practices to avoid any health challenge and economic losses be encouraged. These findings correspond with that of Chinedu *et al.* (2019) who reported that smoked dried fish sold in major markets in Makurdi, Benue State, North-central Nigeria were contaminated by fungi. The present study also established that all the smoked *Clarias gariepinus* sampled from Tella and Mayo-Renowo markets harbored one or more fungi. The result of this study, suggest that fish sold from these markets could have being contaminated from poor handling at harvest, processing and marketing. The spoilage set in on the smoked fish were attributed to the fungal load, which also affect the biochemical reactions, and further increased the levels of the some of the harmful biochemical substances assessed on the sampled smoked fish such as Trimethylamine, FFA, peroxides, proximate composition.

CONCLUSION

The levels of microbial load in the samples collected from the markets were higher than acceptable range, however, for individual fungal species, they were below the recommended ranges, however caution should be taken in consuming fish from the locations for health benefits.

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EFFECT OF ONION JUICE AND ONION CHAFF WASTE AS PRESERVATIVE ON MICROBIAL LOAD OF SMOKED *CLARIAS GARIEPINUS*.

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ABSTRACT

This study explores utilization of Onion juice and chaff waste as fish preservative on *Clarias gariepinus*. A total of thirty (30) samples of *C. gariepinus* were purchased from Eriwe Farm, Ijebu Ode. Fish (10 samples) were dipped in onions juice, 10 fish samples were coated with onion chaff and control fish of 10 samples

without addition of preservative were smoked. A metallic drum smoking kiln was used for the smoke-drying process. The fish samples were then placed on the mesh and smoked samples were stored at room temperature for 8 weeks. Microbial analysis of fish samples was conducted every fortnight according to standard methods. There was significant variation $p < 0.05$ in microbial load of the treated and control sample fish with least growth on onion chaff treatment. The study noted that onion juice and onion chaff are potential preservative agents to be considered in fish preservation due to less microbial load on preserved *C. gariepinus*.

Keywords: Onion-juice, Onion-chaff, fish preservative, microbial count.

INTRODUCTION

Excess production of fish from aquaculture and wild catch with no readily available value chain addition leads to spoilage when processing is limited. Fish value addition is a method of post-harvest loss reduction through adequate processing and preservation to prevent economic loss (Okonta and Ekelemu, 2005). Smoking of fish is presently the best available option in Africa. However, smoked fish have limited storage shelf life when preservative are not added. According to Rathod and Pagarkar (2013) processing methods decreases the protein content due to changes in physical and chemical nature of the fish, thereby resulting in protein denaturation. Different processing methods are known to influence the qualities of fish. Boiling gave fish its best nutritive value, frying ensured a longer preservation. According to Salihu-Lasisi *et al.*, (2013), smoked fish has high protein and fat content, compared to fresh fish. The perishability nature of fish upon harvest necessitated value addition so as to enhance shelf life of fish when adequately stored. High temperature, moisture and processing facilities influenced post-harvest loss. According to Adesehinwa *et al.*, (2005), production from captured fisheries is over 60% of total domestic production per annum, and post-harvest losses from this is estimated at 30-50% of total catches. A 5% post-harvest loss from artisanal production was noted for Africa, and this increased to 10%-20% for the West African Region (Ward and Jefferies, 2000; Famurewa *et al.*, 2017). Various methods have been adopted to reduce these losses such as refrigeration, freezing, salting, brining (wet salting), icing, smoking, glazing, drying, frying to minimize spoilage, enhance quality and increase shelf life (Tairu *et al.*, 2017). In Nigeria, the African catfish *Clarias gariepinus* is an important fresh water fish species (Eyo *et al.*, 2013). Preservative either synthetic or natural extends the shelf life of fish product while maintaining product quality.

Different plant preservatives of the *Allium* family have been documented in research Ifesan (2017) onion peel; Ndimele *et al.*, (2019) and Okereke and Achilike (2021) ginger and garlic. Onion (*Allium cepa* L.) is one of the most widely cultivated species worldwide of the genus *Allium* (Bindu and Podikunju, 2015). The onion bulb is mostly utilized as food condiment and flavor enhancer for various dishes. Due to its richness in phytonutrients as flavonoids, fructo-oligosaccharides (FOS), and thiosulfinates and other sulfur compounds, recognized as important elements of diet (Slimestad *et al.*, 2007). Anti-oxidant properties of onion are due to its high concentration of phenolic compounds which has been used in the treatment of pathologies of degenerative nature affecting human health (Liguori *et al.*, 2017). The flavonoids especially quercetin in onion is been used in pharmaceuticals and nutraceuticals industry (Packia *et al.*, 2015). It has also been used to stomach, brain and cancer of the liver in humans (Mahfouz, 2014) and used to inhibit blood clotting in the heart which can cause stroke. Studies have shown that the concentration of antioxidants is higher in red when compared to white or yellow cultivar (Nuutila *et al.*, 2003; Shon *et al.*, 2004; Rahmat *et al.*, 2018). Since *C. gariepinus* is highly consumed by Nigerians, it is important to establish its best preservation method. The constituent of phytochemicals in onion makes it worthy of consideration; this study thus investigated the effect of onion juice and chaff as preservative on smoked *C. gariepinus*.

Materials and methods

Fish sample preparation.

Thirty samples of *C. gariepinus* average 1kg were purchased from Eriwe Fish Farm Ijebu Ode. The fish were divided into 3 treatments of 10 fish/treatment. The fish was degutted, washed off its slime and drained. Onions of 1kg weight was purchased from the Oke Aje market Ijebu Ode, washed and blended to paste without addition of water, using electric kitchen blender (Binatone: BLG 699). The blended paste was squeezed to pass through a net mesh size of 1mm for its juice while obtaining the chaff waste residue. The fish were degutted, one treatment was dipped into the juice for 10minutes, the other treatment rubbed with the chaff waste, while the third treatment serves as the control without preservative. The three treatments were smoked using a metallic drum smoking kiln for 8 hours. Smoked samples were then stored at room

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temperature for 8 weeks. Microbial analysis was conducted at the start the commencement of storage and every forth night while the storage last according to the method of Adegoke (2004).

Statistical analysis

Data obtained for microbial count of control and preserved fish were subjected to One Way Analysis of Variance (ANOVA) for significant difference using SPSS (Statistical Package for the Social Sciences, version 23).

RESULTS AND DISCUSSIONS

The result of microbial analysis revealed that control fish possess higher loads of microbes compared to the other preserved fish. The loads of microbes increased over the study period, while parameters were significantly different ($p < 0.05$) in onion chaff preserved treatment compared to other treatments.

Table 1: Microbial analysis of fish samples preserved with onion juice and onion chaff.

W k	Control fish sample				Fish preserved with onion juice				Fish preserved with onion chaff waste			
	TBC	TFC	TCC	TVC	TBC	TFC	TCC	TVC	TBC	TFC	TCC	TVC
0	4.56x1 0 ³	1.56x1 0 ¹	0.00x1 0 ¹	6.28x10 ⁵	3.79x1 0 ³	1.31x1 0 ¹	0.00x1 0 ¹	4.88x10 ⁵	4.21x1 0 ³	1.43x1 0 ¹	0.00x1 0 ¹	5.11x10 ⁵
2	5.79x1 0 ³	1.84x1 0 ¹	0.34x1 0 ¹	6.84x10 ⁵	4.13x1 0 ³	1.53x1 0 ¹	0.15x1 0 ¹	5.16x10 ⁵	4.95x1 0 ³	1.67x1 0 ¹	0.24x1 0 ¹	5.49x10 ⁵
4	6.27x1 0 ³	2.11x1 0 ¹	0.41x1 0 ¹	8.40x10 ⁵	4.99x1 0 ³	1.80x1 0 ¹	0.22x1 0 ¹	6.18x10 ⁵	5.35x1 0 ³	1.93x1 0 ¹	0.36x1 0 ¹	6.65x10 ⁵
6	8.19x1 0 ³	2.87x1 0 ¹	0.76x1 0 ¹	11.10x1 0 ⁵	6.25x1 0 ³	2.43x1 0 ¹	0.55x1 0 ¹	8.77x10 ⁵	6.86x1 0 ³	2.60x1 0 ¹	0.71x1 0 ¹	9.09x10 ⁵
8	12.59x 10 ³	4.28x1 0 ¹	1.11x1 0 ¹	17.10x1 0 ⁵	9.98x1 0 ³	4.65x1 0 ¹	1.02x1 0 ¹	15.19x1 0 ⁵	8.53x1 0 ³	3.95x1 0 ¹	0.96x1 0 ¹	13.88x10 ⁵

TBC = Total Bacterial Count, TFC= Total Fungal Count, TCC= Total Coliform Count, TVC= Total Viable Count,

The limits for microbial loads were within the specified range recommended for fish and fishery products by CFS (2014) which categorized food mixed with dressing to be safe at $< 10^7$ CFU/g. Though total coliform count (TCC) was found in the fish preserved with onion juice and chaff, it was noted however that these samples had lower amounts of coliforms in them (1.02 and 0.96 cfu/g) respectively as compared to control fish sample (1.11). In the study of Salaudeen and Osibona (2018) found that total bacteria and viable counts were high in fresh fish and reduced in smoked catfish which was true in their study especially for total coliforms count. The total viable count (TVC) of smoked control (untreated) samples was the highest throughout the period of storage and this sample was even completely covered by mold after the eight weeks of storage. Growth of microbes on fish samples increased with the storage in this study but within the limit for ready to eat food. However, Okereke and Achilike (2021) observed similar growth response but beyond the satisfactory limit. Ndimele *et al.*, (2019) reported that extract and oil of plant preservative possesses inhibitory agents that prevents proliferation of microbes on fish. Ifesan (2017); Bedrniček *et al.*, (2019) reported the ability of onion waste to reduce the CFU/G in stored meat, while Cebin *et al.*, (2020) noted the need to incorporate onion waste as a potential agent for food preservative.

CONCLUSION

The study revealed that *Clarias gariepinus* preserved with onion chaff had less microbial count than *Clarias gariepinus* preserved with onion juice hence the need for consideration of these preservatives in food storage.

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FISHERIES ECONOMICS, EDUCATION AND EXTENSION

USES AND GRATIFICATION OF A RADIO PROGRAMME AGRIC-PANORAMA FOR FISH BUSINESS FUTURE AMONG WOMEN IN KAINJI LAKE BASIN, NIGERIA.

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ABSTRACT

From time immemorial, government uses radio as an instrument to educate the audience on the plan of action and the societal activities of expressing ideas and feelings. This study assessed the uses and gratifications of Radio Agricultural Panorama Programme for the future of fish business among women in Kainji Lake Basin, Nigeria. The study adopted questionnaire interview to generate primary data while Secondary data were from Radio Agricultural Panorama Programme. In analyzing the data, descriptive statistics was employed. Result showed 66.7% for adequate information dissemination to women in Kanji Lake Basin and 80% for routine attendance of the Radio Agricultural Panorama Programme among women in Kanji Lake Basin. It agreed that women are involved in monitoring and evaluation of Radio Agric Panorama Programme in Kanji Lake Basin. The study concluded among others that the level of awareness of Radio Agricultural Panorama Programme among women in Kanji Lake Basin, Nigeria has significantly affected the sustainability (future) of fish business. The study recommended the need for the radio station to improve on high quality signals and should also package well informed agric panorama programme that will help the women to boost their businesses and reduced threat to their livelihood sustainability.

Keywords: Women Awareness, Fishing Business, Women Involvement, Radio Programme.

INTRODUCTION

For centuries ago, radio was accepted as the greatest landmark of details leaders of different movement in the society of human activity of expressing ideas and feelings. On this basis the government engineer radio to educate the audience on the plan of action and the societal issues for developmental programs which is important to development of humanity (Anibueze, 2005). The government radio broadcasting stations broadcast in English, Hausa, Nupe, Gbagi, Bissa, and Kanjari dialects, to their audience on socio-economic developmental programmes which is in collaboration with Radio Niger Koro in New Bussa Kainji Dam transmitting on 98.1K/H with a medium wave band.

Women gender in agriculture are important stockholders that needs Community Radio for mobilization, awareness creation, and to gain knowledge to improve their agricultural rural livelihood particularly in fisheries. According to UNDP (2012), women play a dominant role in agriculture and are believed to make up to 60-80% of the agricultural workforce in Nigeria. Women in agriculture know the important of radio has reliable source of information, hence high ownership of radio and listeners are established in Niger State (Kabir, 2011). In the small-scale fisheries, women's roles are dominant in the post-harvest value-chain in artisanal fishery and aquaculture. They process fish products: drying, salting, smoking, making fish balls or fish/shrimp sauce which they either sell to generate a supplementary income for the family, or use directly for household consumption. Dauda (2005) points out that to ignore the role of women in the fisheries is to discount their potential to strengthen the sector. Therefore, organizations should take advantage of the

presence of radio with its richness, cheapness, speediness and effectiveness to plug into radio programmes in order to extend their frontiers to the women in fishing communities. The aim of this study is to access the perception of female gender on radio agric-panorama programmes to promote fisheries in Kainji lake basin, Nigeria.

Some radio programmes of the National Agricultural Extension Research and Liaison Services (NAERLS), Ahmadu Bello University Zaria, which are being broadcast in different radio stations across the country including radio Niger Koro New Bussa were as follows; (1) **Filin Masunta**: It is an English programme broadcast by Kaduna State Radio which also has its Hausa version known as “**Fish Farmers**. Aquaculture (2) Mu Koma Gona:” is a Hausa programme translated in English language as “let’s Go or Get back to farm”. The programme talks about how to farm which was broadcast by Federal Radio Corporation of Nigeria. (FRCN) Kaduna. Therefore, from these programmes communication creates a lot of ideas, that strengthens the emotions of togetherness, from the exchange of messages, and translation of ideas into thoughts and actions. It is on this fact that Moemeka (1985) stated clearly that “radio communication enlightening citizens on new important topics that are basic in the society and also helps to reach a particular goal of development in the rural communities, as important topics of development are aired to the audience by various programmes. Individuals are aware of the happenings in and around their society through listening to such programmes.” For instance, issues on health, agriculture, politics, economy, sports, culture, empowerment (entrepreneurship), and so on, are aired in order to create awareness to the populace. As a result, therefore, a society that has poor communication and information infrastructure continuing lags behind others that are efficient in information infrastructure (Madu, Umar and Khalique, 2012). It is based on this fact that the government uses radio to communicate its citizenry on its planned developmental programmes, which can influence the lives of the people. In a state like Niger, the areas of health, agriculture, education, shelter, portable water, roads and transportation, electricity, security and other social amenities are addressed during the radio programmes. In this way, an idea was put forward on the ability of the media to broadcast related messages to specific audiences to take such decisions, which on the other way round would ordinarily influence their lives and the environment they are lived in. From this background, it is important to understand that this public will possibly be reached by different platforms that are reliable on the issues, challenges or situations that necessitate the communication or interaction. However, one of the most reliable and emerging media or channels of communication is the radio which could come in the form of advertisement, public relations, sharing activities, discussing the challenges etc. The presence of radio with its richness, cheapness, speediness and effectiveness attracts organization like National Institute for Freshwater Fisheries Research (NIFFR) New Bussa, Niger State who oversees the Kanji Lake Basin to plug into radio programs in order to extend their frontiers to the women in fishing communities.

This lead to the assessment of the effects of level of awareness of Radio Agricultural Panorama Programme among women on the sustainability of fishing business in Kainji Lake Basin, determining the effects of frequency in listening pattern of Radio Agricultural Panorama Programme among women on the sustainability of fishing businesses in Kainji Lake Basin, and assessing the effects of women involvement in Radio Agricultural Panorama Programme on the sustainability of fishing businesses in Kainji Lake Basin.

METHODOLOGY

A three stage sampling technique was used to select the respondents for the study. The communities were selected based on the existing stratification developed in the Institute (Northern, Central and Southern strata). Nine major fishing communities (Monnai, Coverdam, Yunna, TunganAlhaji Danbaba, Musawa, Shagunu, Anfani, Malale and Warra), all riparian communities on kainji reservoir. Data were collected with semi-structure questionnaires through face to face interview. The sampling procedure was done in three stages and based on the initial stratification. The final stage was proportionate and random selection of 10% of the women in each of the 9 communities. Thus a total of 150 women were selected and used as respondents’ women in each of the 9 communities. Thus a total of 150 women were selected and used as respondents for the study. The data was subjected to descriptive statistical analysis of frequency and percentage.

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Design Outlay for the respondents in Kainji Lake Basin.

Existing strata in Kainji Lake Basin	Numbers of women selected in each community		Total numbers of women selected per stratum
1 Northern	Monnai	18	51
	Cover dam	16	
	Yunna	17	
2 Central	T/D.Baba	17	48
	Musawa	15	
	Shagunu	16	
3 Southern	Anfani	17	51
	Malale	18	
	Warra	16	
TOTAL			150

RESULTS AND DISCUSSIONS

To assess the effect of level of awareness of Radio Agricultural Panorama Programme among women on the sustainability of fishing business in Kanji Lake Basin.

	Frequency	Percent	Cumulative Percent
Strongly agree	100	66.7	67.7
Agree	25	16.7	83.4
Undecided	10	6.7	90.1
disagree	10	6.7	96.8
Strongly disagree	5	3.3	100
Total	150	100	

Source: Researcher's field survey, 2021.

Table 1 revealed that 66.7% and 16.7% given accumulative percent of 83.4% of respondents strongly agree and agree that there is adequate information dissemination to women in Kanji Lake Basin; which is in conformity with the study of Gathigi (2009) that radio is the most important medium of communication to the rural dwellers, 6.7% of the respondents are undecided; while 6.7% and 3.3% given a cumulative percent of 10.0% of the respondents disagree and strongly disagree respectively. Based on the response in this table, it implies that there is adequate information dissemination to women in Kanji Lake Basin.

Determine the effects of frequency in listening pattern of Radio Agricultural Panorama Programme among women on the sustainability of fishing business in Kainji Lake Basin.

	Frequency	Percent	Cumulative Percent
Strongly agree	100	66.7	66.7
Agree	20	13.3	80.0
Undecided	10	6.7	86.7
disagree	15	10.0	96.7
Strongly disagree	5	3.3	100
Total	150	100	

Source: Researcher's field survey, 2021.

Table 2 shows the effects of frequency in listening pattern of radio with respect to whether there is routine attendance of the Radio Agricultural Panorama Programme among women in Kanji Lake Basin. This revealed that 66.7% and 13.3% given accumulative percent of 80% of respondents strongly agree and agree that there is routine attendance of the Radio Agricultural Panorama Programme among women in Kanji Lake Basin which agrees with the findings of Mogambi (2016) which revealed that women have easy access to

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radio through their spouses, while 10.0% and 3.3% given a cumulative percent of 13.3% of the respondents disagree and strongly disagree respectively. Based on the response in this table, one may come to a conclusion that there is routine attendance of the Radio Agricultural Panorama Programme among women in Kanji Lake Basin.

Assess the effects of women involvement in Radio Agricultural Panorama Programme on the sustainability of fishing businesses in Kainji Lake Basin.

	Frequency	Percent	Cumulative Percent
Strongly agree	100	66.7	66.7
Agree	30	20.0	86.7
Undecided	10	6.7	93.4
disagree	8	5.3	98.7
Strongly disagree	2	1.3	100
Total	150	100	

Source: Researcher's field survey, 2021.

Table 3 shows the assessment of women involvement in monitoring and evaluation of Radio Agric Panorama Programme in Kanji Lake Basin, this also revealed that 66.7% and 20.0% given accumulative percent of 86.7% of respondents strongly agree and agree that women are involved in monitoring and evaluation of Radio Agric Panorama Programme in Kanji Lake Basin; while 5.3% and 1.3% given a cumulative percent of 6.6% of the respondents disagree and strongly disagree. Based on the responses, it implies that women are involved in monitoring and evaluation of Radio Agric Panorama Programme in Kanji Lake Basin.

CONCLUSION AND RECOMMENDATIONS.

Women's level of awareness and involvement of Radio Agricultural Panorama Programme in Kanji Lake Basin, Nigeria has significantly affected the sustainability (future) of fishing business. The study recommended among others the need for the programme to be detailed enough to address the women's needs and include other economic activities so as to help have other sources of income, especially during the dry season to prevent overfishing, also the radio station to improve on high quality signals and package well informed agric panorama programme that will help the fish processors to boost their businesses and also reduced threat to their livelihood.

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THE EVALUATION OF FRESH FISH MARKETING STRUCTURE IN GAMBORU FISH MARKET, MAIDUGURI, BORNO STATE, NIGERIA

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ABSTRACT

The evaluation of fresh fish marketing structure in Gamboru fish market Maiduguri, Borno State, Nigeria was carried out with the aim of determining the socio-economic characteristics of fresh fish marketers, assessing the performance of fresh fish marketing in Maiduguri and identifying the various channels of fresh fish marketing and distribution. Data were collected with the use of questionnaire and structural interview with the marketers; Simple random sampling technique was used to select 60 respondents of fresh fish sellers from Gamboru market, Maiduguri metropolitan area of Borno State. The statistical analysis used in this study are descriptive statistics such as frequency distribution mean and percentages, marketing margin, gross margin and marketing efficiency were used to analyze the data. The result indicated majority (93.3%) of the marketers were males, while 6.7% were females. Age range of marketers indicated that 30% of the marketers were 40 and above years. Majority (37.7%) of marketers had Qur'anic education, (1.8%) lacked formal education. The years of marketing experience showed that (45%) had 16 years and above marketing experience (13.2%) with 1 – 5 years of experience. Majority (66.1%) of marketers were full-time marketers of fresh fish, signifying that it is a profitable business. The performance of the fresh fish market from gross margin and marketing margin analysis implied that fresh fish marketers made profit, with a gross margin of N66,214,650 annually, while the marketing margin indicated an unacceptable marketing performance of 19.5%. The marketing efficiency of the markets gave (3.51%) showing an inefficient market system. Marketing channel of fresh fish identified in the study showed the supply of fresh fish from aquaculture (53.3%) and (25%) from the wild while (21.7%) was gotten outside Maiduguri. It is however, concluded that though fresh fish marketing is profitable, the marketing system is inefficient and the performance of fresh fish marketers is unacceptable. Therefore, it is recommended among others that market information on the part played by producers, wholesalers and retailers is essential and formation of cooperative by marketers would help in reducing storage cost.

Keywords: fresh fish, marketing structure, Gamboru market, fish marketers

Introduction

The human body utilizes protein from fish better than the protein from milk, beef, pork, chicken, etc (Adekoya, 2004). The author also opined that protein from fresh fish are adequate, important and digestible. Fish is also valued as a source of omega – 3 – fatty acids which is essential for the development of the brain and retina (FAO, 1991). Marketing of fresh fish refers to the performance of all activities involved in the flow of fresh fish from the point of initial production to final consumers (Olukosi *et al.*, 2005). Fish whether fresh or processed is aimed at the consumers and it must get there in acceptable form. Fish is highly perishable and its rapid deterioration is aided by the high temperatures of the environment. Fresh fish must therefore be marketed within few hours of been caught. Another advantage is that, it eliminates additional cost in the process of preservation such as labour cost and firewood to smoke the fish. A reasonable price is always obtainable for good quality fresh fish. Consequently, good marketing strategy must be such that it gets the fish to the consumer in an excellent condition. The prime aim of a fish marketer is to offer good quality fresh fish product to the consumer at a reasonable price.

Marketing performance is defined as the strategic end result of market adjustments engaged in by buyers and sellers (Olukosi *et al.*, 2005). The main features used in assessing market performance are the level of profit, scale and utilization of plants and firms, sales and promotion costs, character of the product and progressiveness. The major indicators of market performance are gross margin, marketing margin and marketing efficiency (Olukosi *et al.*, 2005). Marketing margins of more than 15% indicates unacceptable market performance. However, great care must be used in making conclusions based on marketing margin values alone as many other factors as transportation, storage facilities, credit facilities, tax etc influence the performance of a marketing system. (Ali *et al.*, 2008).

In relation to this study marketing efficiency can be referred to as the movement of fresh fish from the producers to consumers at a lowest cost consistent with the provision of the services to consumers. Small marketing margin indicate or proofs that marketing is efficient. Marketing margin is the difference between the farm gate price and the retail price received (Olukosi *et al.*, 2005). Under marketing channel, the primary marketing of fish especially fresh fish starts from the home gate of the fishermen who are the primary sources of fish to middlemen where most transactions take place. This study aimed at determining the socio-economic characteristics of fresh fish marketer, assess the performance of fresh fish marketing in Maiduguri metropolitan area of Borno State and identify the various channels of fresh fish marketing and distribution.

Methodology

Study Area

The area of study is Gamboru fish market, Maiduguri metropolitan area of Borno State which is one of the 27 Local Government Areas, as well as the State Capital of Borno State. The state occupies a total land mass of about 50, 778 square kilometers. It lies between latitude 11⁰ and 14⁰ east and longitude 10⁰ and 14⁰ North (Bureau of Land and Survey, 2012). It is located within the semi-arid zone of West Africa and Sahel Savannah Zone of Northern Nigeria, at an elevation of about 55 meters above sea level (Department of Land and Survey, 2010 and Federal Office of Statistic Annual Report, 2009).

Sources of Data

Both primary and secondary data were used in this study. Primary data was generated from the use of questionnaires and structural interview in situations where the respondents are unable to read or write and their responses were entered accordingly. Secondary data were obtained from journals, seminar papers on fisheries, fisheries publications and websites.

Sampling Procedure

Simple random sampling technique was used to select 60 respondents of fresh fish sellers in Gamboru market, Maiduguri metropolitan area of Borno State.

Methods of Data Analysis

The Statistical analysis used in this study is descriptive statistics such as frequency distribution, mean and percentages. The following were analyzed:

Marketing Margin Analysis

$$MM = \frac{\text{mean selling price of fresh weight basin of fresh fish} - \text{mean supply price of fresh fish} / \text{mean basin of fresh fish}}{\text{Mean selling price of fresh} / \text{mean weight basin of fresh fish}} \times 100$$

Gross Margin Analysis

$$GM = TR - TC$$

Where:

GM = Gross Margin

TR = Total Revenue from the sales of fresh fish

TC = Total cost of fresh fish

$$\text{Marketing Efficiency} = \frac{\text{value added by marketing}}{\text{cost of marketing services}} \times 100$$

RESULTS AND DISCUSSION

Table 1 below shows the predominant age of fresh fish marketers ranging from 41 and above (30%), followed by 10-20year (25%), 21-30 year (23.3%), and (21.7%) for the age group of 31 –40 years while age 41 and above accounted for 30%.

Table 1: Age Distribution of Respondents in Gamboru fish market

Age (Years)	Frequency	Percentage (%)
10 – 20	15	25
21 – 30	14	23.3
31 – 40	13	21.7
41 and above	18	30
	60	100

Table 2 below shows that male respondents (93.3%), formed a greater proportion of fresh fish marketers in the study area while female were 6.7%.

Table 2: Sex Distribution of Respondents in Gamboru fish market

Sex	Frequency	Percentage (%)
Male	56	93.3
Female	4	6.7
Total	60	100

Figure 1 below revealed that majority of the respondents (37.7%) had Qur'anic education, 20.7% attended primary education, 16.9% obtained secondary certificate, 15% acquired adult education, 8% attained higher education and 1.8% had no formal education.

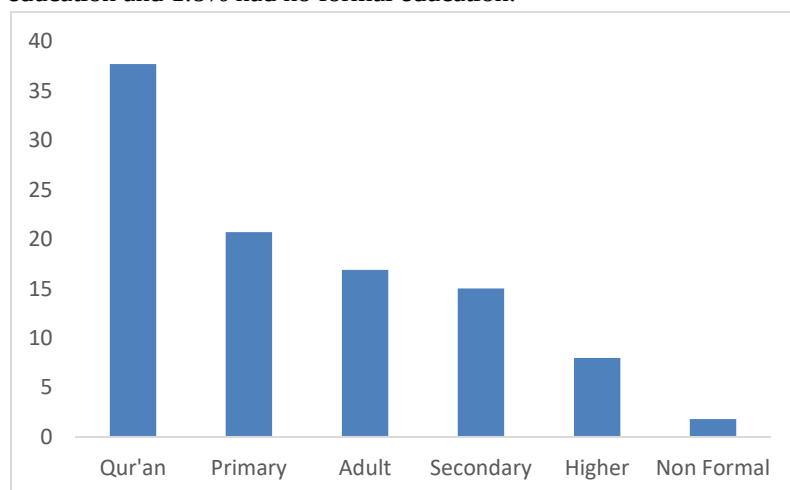


Figure 1: Educational Qualification of respondents in Gamboru fish market

Figure 2 below provides information on the primary occupation of respondents. 13.2% of respondents were involved in farming activities, 60.1% had been in the business of selling fresh fish, 9.4% traded other commodities, while 11.3% was involved in hand craft business

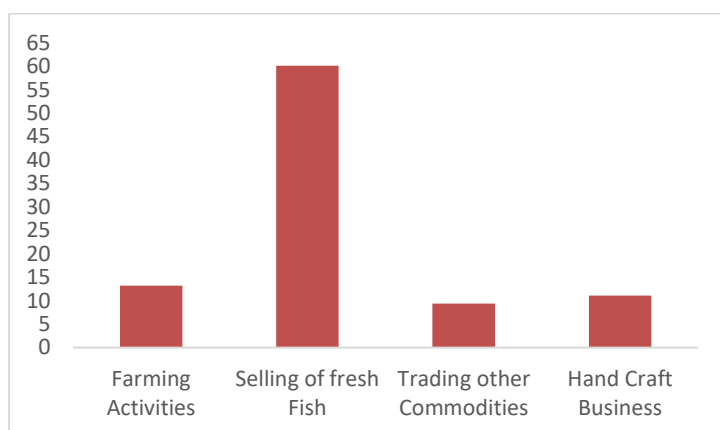


Figure 2: Primary occupation of respondents in Gamboru fish market

Table 3 below revealed that marketers with 1 – 5 years of experience constituted 13.2%, 28.3% for marketers within 6 – 10 years, while marketers with 16 and above years of experience constituted 45%.

Table 3: Distribution of Respondents based on Years of Market Experience in Gamboru fish market

Experience (Years)	Frequency	Percentage (%)
1 – 5	7	13.2
6 – 10	15	28.3
11 – 15	11	20.8
16 and above	27	45
Total	60	100

Table 4 shows that the annual gross margin of the market is ₦66,214,650 and the marketing margin at 19.5%.

Table 4: Annual Gross Margin Analysis in Gamboru Fish Market

Item	Total Amount (₦)	Mean Amount (₦)
Total Revenue	82,639,650	1,559,238.6
Variable Costs		
1. Storage	5,475,000	103,301.8
2. Transportation	10,950,000	206,603.7
Total Variable Costs	16,425,000	
* Annual Gross Margin	* 66,214,650	
** Mean Total Variable Cost		** 309,905.5

Table 5 below revealed that the marketing efficiency of the Gamboru fish market is 3.5%

Table 5 Marketing Efficiency of Fresh Fish Marketers in Gamboru Fish Market

S/N	Item	Amount (₦)
1.	Value Added by Marketing	578,000
2.	Cost of Marketing Services	16,425,000
3.	Marketing Efficiency	3.51%

Figure 3 below shows the channel of fresh fish marketing. Majority of the marketers (53.3 %) bought from Aquaculture, (25%) from the wild, while 21.7% got their supply outside Maiduguri.

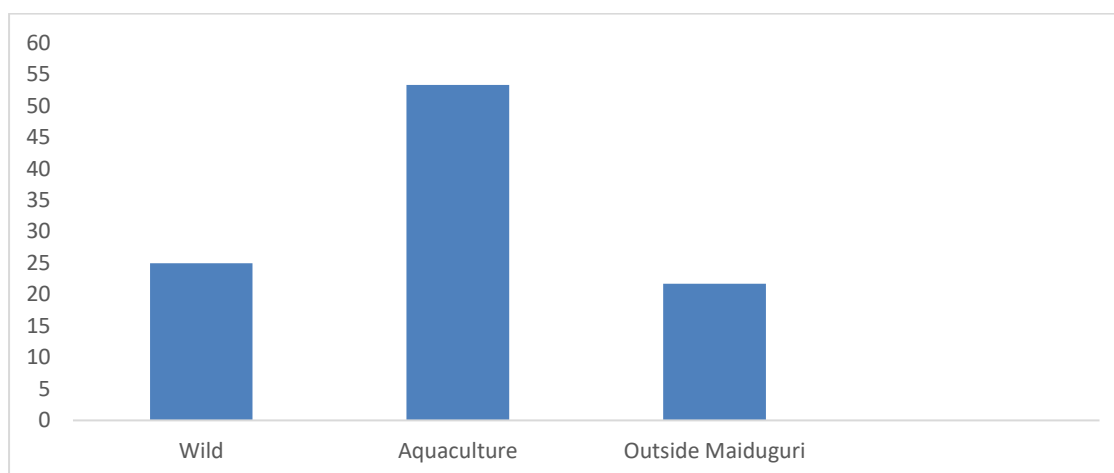


Figure 3: Fresh fish marketing distribution of Gamboru fish market

Table 6 below revealed the supply of fresh fish to respondents by producers, retailers and wholesalers. Retailers constituted the least (25%); while the producers (33.3%) and wholesalers constituted majority (41.7%).

Table 6: Distribution of Respondents based on the Supply of Fresh Fish in Gamboru fish market

Suppliers	Frequency	Percentage (%)
Producers	20	33.3
Retailers	15	25
Wholesalers	25	41.7
Total	60	100

The study showed that 93.3% of the marketers were males, which implies that women do not participate actively in fresh fish marketing. This result agrees with the findings of Sule and Raji (2001) who pointed out that fish marketing is an exclusive business for males. Majority of the respondents fell within the age group of 40 and above with 30% indicating that they are in their economic active years. This supports the findings of Mele (2007) who's study on fresh fish marketing in Dadin-Kowa, Gombe State revealed that youths and middle aged groups were the most involved in fresh fish marketing. 37.7% of respondents had Qur'anic education. This result agrees with the findings of Lawal and Idega (2004) which showed that low level of education by marketers to a large extent determines the strategies they would use to solve their marketing problems. The primary occupation of respondents revealed that 66.1% were fully involved in fresh fish marketing. 45% had 16 years and above experience in marketing of fresh fish, which implied that majority of the marketers have been in the business for long. This result is in line with the findings of Ali *et al.* (2008), which revealed that marketing experience is a tool in determining the knowledge and profit marketers tend to get. The performance of fresh fish marketing implied that marketers made profit with gross margin of N66,214,650 annually. The marketing margin gave 19.5% indicating that the performance of the market is unacceptable; this result is in line with the findings of Ali *et al.* (2008), who observed that marketing margins of more than 15% indicated an unacceptable market performance. The marketing efficiency of fresh fish market showed that the market is inefficient (3.51%). This is a very low percentage which implies that the marketing of fresh fish in Gamboru fish market is not efficient. This agrees with the study of Olukosi *et al.* (2005), which pointed out that a low percentage signifies the inefficiency of a market, while a higher percentage shows the market is efficient.

The supply of fresh fish to marketers indicated that wholesalers (47.2%) were in control of fresh fish supply in the study area. This finding is in line with the findings of Gadu (1998) whose work indicated that wholesalers controlled the supply of fresh fish in the same area of study.

CONCLUSION

Based on the findings of this study, it is concluded that fresh fish marketing though profitable in the study area with Gross Margin of N66,214,650 annually, the marketing system is not efficient and the performance of fresh fish marketers is unacceptable. This would tend to limit the profit made in the study area.

RECOMMENDATIONS

The following recommendations were made to improve the performance of fresh fish marketers in the study area:

- (i) Producers, wholesalers and retailers should be well informed about the market and general conditions of the market.
- (ii) Fresh fish marketers should form cooperative societies, to enable them access loan and provide storage facilities so as to reduce the cost of storage.
- (iii) Extension agencies should educate fresh fish marketers on technical knowledge on marketing through extension education programmes.

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CONSTRAINTS AND PROSPECTS OF FISH FARMING AMIDST COVID-19 IN BAUCHI METROPOLIS

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ABSTRACT

This research was conducted to identify constraint of fish farming amidst Covid-19 in Bauchi metropolis, thirty questionnaires (30) was distributed to some fish farmers around Bauchi metropolis, the result shown on

the impact of Covid-19 on fish farmers which has a negative effect on fish farming, with report to the price of fingerlings, e.g fish feed and table sized fish. Fish feed price increment was almost 10-15% which led to increase in price of fingerlings as well as the table size fish. The method of data analysis used was percentage and frequency which was presented in tabular form. Based on the result, it can be concluded that, fish farmers have experienced downfall in fish farming business as a result of the pandemic (Covid – 19). So it is recommended that government should intervene in fish farming sector so as to prevent total downfall of fish farming in Bauchi.

KEYWORDS:

INTRODUCTION

Fish farming contributes significantly to the economy, creating employment opportunities in rural and urban areas, serving as a viable source of protein nutrients in Nigerian households and improving national food security. In 2009, fish accounted for 16.6 percent of the world population's intake of animal protein and 6.5 percent of all proteins consumed (FAO, 2012). Global outbreaks like Ebola, SARS and MERS all had negative impacts on food and nutrition security, particularly in the developing countries and for vulnerable populations like children, women, old and the poor (Hossain, 2020). The pandemics that the world has experienced earlier, has been shown that quarantines and panic not only affect the human activities and economic growth (Hanashima and Tomobe, 2012; Bermejo, 2004; Arndt and Lewis, 2001); but also affects the aquatic food systems and all sorts of agricultural activities that induces increase in hunger and malnutrition (Burgui, 2020) (Saret *et al.*, 2010). Global outbreaks like Ebola, SARS and MERS all had negative impacts on food and nutrition security, particularly in the developing countries and for vulnerable populations like children, women, old and the poor (Hossain, 2020). In 2014, when Ebola epidemic hit Guinea, Liberia and Sierra Leon, price of domestic rice increased by 30% while the price of cassava, a major staple in Liberia, increased by 100% (Fan, 2020). If the COVID-19 pandemic continues in such a way the production of agricultural crops, aquatic foods and livestock such as wheat, rice, vegetables, fish, sea food, egg, meat and dairy will be affected. According to the Food and Agriculture Organization of the United Nations (UNFAO) more than 820 million people around the world are suffering from hunger. The world is already facing food and nutrition security challenges where the situation of the less developing, developing and lower middle countries is more vulnerable (FAO, 2020).

Objective of the Study

The main objective is to evaluate the constraint of fish farming amidst Covid-19 Pandemic in Bauchi Local Government.

The species objectives are as follows:

1. To find out the challenges faced by fish farmers in Bauchi metropolis during Covid-19
2. To find out solution to the challenge faced by fish farmer in Bauchi metropolis

MATERIALS AND METHOD

Bauchi local government area (L.G.A.) is located between 10°-17N and longitude 90-45E. It is situated within northern Guinea Savannah ecological zone of Nigeria and has elevation of 690.20 meters above the sea level. The climatic condition of the area is characterized by two district season, dry and wet. The wet season last five (from May to September). While the dry season begins in October and ends in April (7 months).

Research Design

The study adopted a descriptive research design aimed at collecting data for the purpose of finding out the impact of Covid-19 on fish farming in Bauchi local government. The study adopted well-structured questionnaire in the collection of the data from consumers and fish sellers within Bauchi.

Sampling Techniques

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A simple random sampling technique was employed with some selected fish farmers in Bauchi. Federal Polytechnic and Gwallamejiwas chosen as the study location.

Method of Data Collection

Both qualitative and quantitative data were collected during the study using questionnaire.

Method of Data Analysis

To achieve the objectives, the generated data was summarized into frequencies and percentages which are presented in tabular forms. Variable relationships were analyzed mainly by cross tabulation. Content analysis method was used to analyze the information generated from semi structured interviews.

RESULTS

Based on the result presented, in table 1, the minimum price of fingerlings before covid-19 shows 43.34% of the price level which is higher during covid-19 is 53%. Therefore, almost 10-15% of the price of fingerling is increased as result of the pandemic. Fish farmers recorded optimum loss during covid-19 almost 73.33% as a result of lockdown and restrictions. Fish feed, being one of the basis of fish farming was also higher in price during covid-19 as shown in the table 1 is 53% which is an increase of almost 30% of the price before covid-19 chain this confirms to the study by (Onumah et al., 2020, CRC, 2018; Cheke, 2014). However, the age and other factor did not have any effect on the marketing or sales ability of the sellers which contradict the study by Onumah et al. (2020) found that demographic factors have positive and significant influence on fish sales

Table 1: The price frequency of fingerling, fish feed & table size fish catfish before covid-19 and during Covid-19

	Before Covid-19	During Covid-19
Price (₦)		
Price of Fingerling	Frequency	Frequency
₦30 - ₦35	H = 10	H = 7
₦35 – ₦40	L = 15	L = 5
₦45 – and above	VH = 5	VH = 18
Price of Fish feeds		
	H = 8	H = 9
	L = 8	L = 6
	VH = 14	VH = 15
Price of table size		
₦ 800 - ₦900	H = 10	5
₦900 - ₦1000	L = 15	25
₦ 1000 and above	VH = 5	0

Table 2: The result showing the percentage level of loss experience and intervention rendered by government or NGOs before and during Covid-19

	Before covid-19	During covid-19
Loss experienced based on capital.	6.67%	93.33%
Intervention received from Government or NGO.	None	None
The amount of fish produced by farmers.	73.33	23.22

DISCUSSION

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The research shows that price of fish feed, fish fingerling was higher during the Covid-19 pandemic, which is as a result of lock down measures implemented by the government, which hinder the transportation of fish, from the farmer to the consumer, it was found that, little to intervention was provided to the farmers to cushion the effect of Covid-19 outbreak which conform what was reported by (Kanal et Al, 2020; Asogwa and Asogwa, 2019; Cheke, 2014.

CONCLUSION: From the research conducted fish farming is an import sector of the economy, the research also shows heavy losses recorded by most fish farmers during the covid-19 pandemic, government need to provide some form of intervention in order to cushion the impact of the pandemic.

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Socio-economic and constraints of unemployed youth and women participating in fish farming entrepreneurial training in Maiduguri, Borno State

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ABSTRACT

This research was conducted to study the Socioeconomics characteristics of Entrepreneurial training of unemployed youth and women in fish farming examine. A sample of (100) respondents were selected for the study to generate both primary and secondary data which were analyzed using descriptive statistical. The results of the study revealed that majority of respondents 54.40% are females while 45.60% are males. The majority of the respondent are within the age bracket of 31-40, 38.20% while the less percentage are within the age bracket of 41 and above 14.70%. The 39.70% of the respondents attended tertiary institution and 1.50% of respondents attend Non formal education. the majority of respondents are unemployed which is 54.40% a while 20.60% of respondents are engages in business activities; This shows that majority of the respondents are married which 60.30% and less is 2.90% of respondents are divorcee.

Key words: Entrepreneurship, Fish farming, Unemployed , Youth, Women

INTRODUCTION

Nigerians are large consumers of fish and it remains one of the main products consumed in terms of animal protein. Only about 50% of demand for fish is currently being met by local supply. Belhabib *et al.* (2015) reported that the fisheries sector contributes 3.5% of Nigeria's growth domestic product (GDP) and provides direct and indirect employment to over six million people. Besides, Nigeria has many rivers and water bodies which serve as good locations to set-up fish farms. Nutritionally, fish is preferred to other kinds of meat and this is evident in the ever-increasing demand for it. The benefits accruing from fish thus, necessitate its production.

Entrepreneurship according to Agomuo (2002) is a process of bringing together creative and innovative ideas, combining them with management and organization skills in order to combine people, money, and resources to meet an identified need. In the view of Okeme *et al.* (2014) entrepreneurship is the process through which individuals combine human and material resources in order to provide goods and services desired by man. Entrepreneurship in fish production with a myriad of activities cannot be effectively pursued without requisite skills

The roles played by youth and women in meeting the challenges of agricultural production and development are quite prominent and this cannot be trivialized. Findings from a study by the United Nations Development Programme (UNDP) revealed that youths and women make up some 60-80 percent of agricultural labour force in Nigeria (World Bank, 2003). Depending on the region, they produce two thirds of the food crops. Sadly, female farmers in the country are among the voiceless, especially with respect to influencing agricultural policies. Such policies, which are aimed at increasing food production and food security, tend to under estimate and totally ignore women's role in both production and the general decision-making process within the household.

One of the greatest social problems facing Nigeria since the re-commencement of democratic rule on 29 May, 1999 is the menace of youth insurgency. This situation is a state of insecurity that exists in an environment arising from individuals or groups that have a feeling of dissatisfaction, marginalization or inequality. The return to democracy in Nigeria brought hopes of rapid development and political stability but the last decade has experienced an upsurge in violent conflicts and criminality, which tended to undermine those expectations. The violence and criminality have come in the form of armed robbery, kidnapping, bombing, ethno-religious militancy, intra and inter party clashes, murder, hostage taking, rape, riot, cultism, vandalism, arson, drug trafficking, arms smuggling, human trafficking among others which have significantly undermined the internal security and economic development of the nation. The role of

youths in Nigerian generally as critical actors in insurgency does not guarantee peace and national development hence, the need to adequately engage them in viable alternative ventures (Eyo, 2000).

Study Area

Maiduguri is located between latitudes $11^{\circ} 42'N$ and $12^{\circ} 00' N$ and longitudes 12.54 and $13^{\circ} 14' E$. Maiduguri covered an area of 543km^2 . The city is bounded in the north by Jere LGA, in the west, south and south-west by Konduga LGA, in the north-west by Mafa LGA. Maiduguri has mean annual maximum temperature of 34.8 with mean temperature ranging between 30°C and 40°C . The months of March and April are usually the hottest months, while November and January are the cold and dry periods of harmattan. The city receives rainfall from June to September. However, in rainy years, the city records rainfall earlier than June and later than September. Being a nodal city, trading is the major occupation of the inhabitants with few agrarian practices. The city is situated in a plain area. One of the problems confronting the geography of Maiduguri urban is the non-availability of a standard boundary of the urban. Therefore, in this study, the urban is defined to be the areas between latitudes $11^{\circ} 27' 30'' N$ and $11^{\circ} 33' 30'' N$ and longitudes $13^{\circ} 2' 30'' E$ and $13^{\circ} 9' 10'' E$.

The primary and secondary data were collected from direct interviews, personal observations and responses of the respondents to questionnaires administered in some selected streets around Maiduguri Metropolis in Borno State and interview was conducted with an agent of a private waste management in the study area.

The research design that was adopted in this study is the social-science design under which the survey design techniques was adopted. Interview were conducted for the youths and women and also questionnaires were administered to the general community in the selected locations in the study area.

Population of one hundred (100) respondents were selected, and one hundred (100) questionnaires were administered to have a representation of the various groups of respondents in the study area. The first stage in the collection of primary data involved the reconnaissance survey of the study area, to enhance familiarization and also facilitates the easy administration of questionnaire. The second stage involves oral interview with both youths and women in the study area. As a result of the homogeneity of the target population these samples size were given a well representation of the sample frame.

In this research, random sampling techniques were used due to the largeness of the frame of the study area.

Methods of Data Analysis

Analysis of data for this study was done considering the different objectives that were used to achieve this study which included the questionnaire and other primary data. Each of these data set was processed and analyzed separately based on each objective of the research. Where descriptive frequency was used.

RESULTS AND DISCUSSION

Table 1:Socio-economic Characteristics of the Respondents

Socio-economic	Frequency	Percentage
Age		
<20	14	20.6%
20-30	18	26.5%
31-40	26	38.2%
41 and above	10	14.7%
Gender		
Male	31	45.6%
Female	37	54.4%
Marital status		
Single	22	32.4%
Married	41	60.3%
Divorced	2	2.9%
Widow	3	4.4%
Family size		

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1—4	35	51.5%
5—9	18	26.5%
10—15	12	17.6%
16-20	3	4.4%
above 20	0	0.0%
Educational background		
Non-formal	1	1.5%
Quaranic education	11	16.2%
Primary education	4	5.9%
Adult education	4	5.9%
Second education	21	30.9%
Tertiary education	27	39.7%
Occupation		
Civil servant	17	25.0%
Business man	14	20.6%
Unemployed	37	54.4%

Source: Field Survey, 2021

The results of the study revealed that majority of respondents 54.40% are females and 45.60% are males this shows that women had a higher number of participant than male, the training programmed was empowered women so as to become self-employed and also gender does not prevent women from participation in training exercise. Age the majority of the respondent are within the age bracket of 31-40 has the highest percentage of 38.20% while the least percentage had 14.70% at the age of 41 and above, this indicated that age have important role to play in training participation youth are very active and willing to learn in the training activities and willing to do whatever ask to do during the training programmed, while less percentage are due to the old agenesis and other factors associated with age. Education also has vital role to play toward youth and women participation in training programmed it can serve and guide and directing ones toward achieving his/her goals and objectives in life time this indicated that the majority of the respondents 39.70% attend tertiary institution of learning and 1.50% of respondents attend non-formal education, this showed that majority respondents are graduate and educated and based on the knowledge, it help them to facilitate better understanding and making used of the knowledge impacted on them during the training programmed. Occupation is the activity one engages the majority of respondents are unemployed which is 54.40% and this shows they are so eager to learn the training exercise so that to become self-employed, while 20.60% of respondents are engages in business activities; this is because they have something to do that is reason why their participation is low. Marital status is also had an important roles to play due to tradition and norms and values in the society but never the less the essence of the training is to empowered women to become self-employed and to handle some of the family responsibilities and this shows that majority of the respondents are married which 60.30% and less is 2.90% of respondents are divorcee and this shows that married and other societal does not prevent training participation of both men and women.

Conclusion

It was concluded that the most of the participant on training are unemployed youth and women and it was found that training is beneficial to them

Recommendations

1. Starter pack such as plastic tank, pelletizing machine should be given to the participant.
2. Soft loan should be given to the participant through the agricultural bank or from cooperative union.
3. Fisheries expert from the college should visit the established farms from time to time.

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ASSESSMENT OF PHYSICAL ASSET TO SUPPORT LIVELIHOOD ACTIVITIES IN YUNAWA A RESETTLED FISHING COMMUNITY IN KAINJI LAKE BASIN, NIGERIA

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ABSTRACT

The study examines the assessment of physical assets to support livelihood activities in Yunawa, a re-settled fishing community. Multi-stage sampling technique was use to select 117 fishers from the four villages that make up Yunawa community. Data analysis was done using descriptive statistics. A total of 28% of the fishers were active participants of political group, 22% were active in youth group while 3% were active on social media group. Schools and access road were part of their physical asset that is most functional while electricity is the least functional asset in the communities. Majority of the fishers own and have access to motorcycle but can't make use of their fishing equipment because they have been re-settled away from the lake basin. The study recommended that fishers in Yunawa should diversify and adopt alternative livelihood strategy so as to cope with the effect of their re-settlement.

KEYWORDS: Physical asset, livelihood and fishing communities

INTRODUCTION

Rural communities in Nigeria have suffered some neglect in terms of development over the years. Most of these communities are isolated and the community members are dependent mostly on the natural resource base for their survival and well-being. Communities in Kainji Lake Basin (KLB) and New Bussa environs are not exceptional to that fact and their major resource base (fishery) is fast depleting due to poor management and over exploitation. This study is concerned with the interrelated issue of physical asset accessibility, diversification of rural livelihood and well-being of the fishers, which are considered central to the achievement of fisheries and community development. These assets are fundamentally useful for them to diversify into other livelihood portfolios and thereby generate more income and resilience, particularly to address the reoccurring stringent issues of seasonality and vulnerabilities.

Diversification is increasing in rural areas, as at the start of the new millennium, roughly 25% of rural full time employment and 35%-50% of rural income were attributed to the rural non-farm economy in developing countries (Reardon, 1997; Ellis, 2000; Haggblade *et al.*, 2007; Bedeke, 2013). One important

pathway towards sustainable livelihood involves the avoidance of long-term dependence on only one or two income sources (Block and Webb, 2001). Therefore, livelihood diversification as a livelihood strategy is considered a direct measure of enhancing access to food in food deficient households, and also makes it possible for the poor to seize the opportunities open to them in the rural sector for attaining sustainable livelihood. The study determines membership of social group, identify community physical asset, and ascertain ownership of personal fishing assets.

Methodology

The study was carried out in resettled fishing communities in Kainji Lake Basin, Nigeria. Multi-stage sampling technique was used for the study. The sampled communities include the following: Sabon Yunawa, Tudun faila, Gidan zare and Tungan gare. Purposive selection of the resettled communities, followed by the proportionate and random selection of 10% of the fishers in each of the 4 communities. Thus a total of 117 fishers was selected and sampled for the study. Relevant data were collected from the respondents through face to face interaction, structured, interview schedule. Statistical package for social science (SPSS) version 20 was used for the data analysis; data collected were subjected to descriptive statistics.

RESULTS AND DISCUSSION

Membership of social group

Table 1 shows that, (23.9%) of the respondents in the study area were active members of a political party, while (18.8%) of the respondents were active members of youth group, (16.2%) of the respondents were also active members of adashe loan group and only (4.3%) of the respondents were members of cooperative group respectively. The importance of social group or social assets cannot be overemphasized particularly in rural communities where lack of voice, strength and inadequate resources particularly finance are constant realities of their economic life. Social group are necessary to enhance their productivity and facilitate their ability to diversify their livelihood portfolios in order to maximize their economic benefits and well-being (Tafida *et al.* 2011).

Table 1: Respondents membership of social group

Membership of social group	Active Freq.	%	Passive Freq.	%	No Freq.	%
Cooperative group	5	4.3	4	0.9	111	94.9
Farmers group	16	13.7	7	6.0	94	80.3
Youth group	22	18.8	6	5.1	89	76.1
Community development group	18	15.4	5	4.3	94	80.3
Security group	13	11.1	5	1.7	102	87.2
Political party	28	23.9	5	4.3	84	71.8
Social media group	0	0	0	0	117	100
Leader group	10	8.5	1	0.9	106	90.6
Adashe loan group	19	16.2	3	2.6	95	81.2

Source: Field Survey, (2020)

Multiple Response

Community Physical Asset

The result in table 2 shows the actively used physical assets in the communities, (99.1%) of the respondents in the study area actively use mosque for their place of worship, (98.3%) of the respondents actively use school, (95.7 %) of the respondents' actively have access road, (90.6%), 73.55% of the respondents used an active hospital and market. The findings equally show that these communities are without other basic necessities such as Electricity, public toilet, town hall and GSM, table 2 also shows that (0.9%) (0.9%) (0.9%) of the communities are without these physical assets respectively. Lack of electricity presents a great

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impediment to engagement into other important livelihood portfolios services such as barbing, grinding/processing, operation of cottage industry

Table 2: Physical Assets of Community

Community physical assets in community	Active Freq.	%	Dormant Freq.	%	No Freq.	%
Hospital	106	90.6	9	7.7	2	1.7
Borehole	48	41.0	54	46.2	15	12.8
School	115	98.3	1	0.9	1	0.9
Market	86	73.5	30	25.6	1	0.9
Access road	112	95.7	1	0.9	4	3.4
Well	36	30.8	8	6.8	73	62.4
GSM network	30	25.6	9	7.7	78	66.7
Electricity	1	0.9	0	0	116	99.1
Public toilet	6	0.9	0	0	116	99.1
Football field	101	86.3	3	2.6	13	11.1
Town hall	7	0.9	0	0	116	99.1
Mosque	116	99.1	0	0	1	0.9

Source: Field Survey, (2020) Multiple response

Personal physical assets

Table 3 shows personal physical assets owned by the respondents in the study area, which shows that, (35.9%) of the respondents owned net for fishing, (33.3%) owned canoe, (27.4%) owned hook and line for catching fish. The result also shows that (35.0%) owned banda for processing of fish, (35.9) owned seeds used in farming crops, the result also indicated that (16.2%) (16.2%) (15.4%) of the respondents only has access to personal physical assets such as, tractor, pesticide and fertilizer used in farming crops respectively. The respondents also lack some of this personal physical asset which can enhance their productivity and well-being such as pond, pumping machine, water quality kits, personal borehole and generator, modern kiln, radio, TV, viewing centre, motor vehicle, and restaurants are not owned nor have access to them. Furthermore, the result shows that (28.2%) owned mobile phone, (43.6%) owned motor cycle used for okada riding as a means of daily income.

Table 3: Respondents personal physical assets

Personal physical assets	Own it Freq.	%	Have access Freq.	%	No Freq.	%
Engine Boat	14	12.0	0	0	103	88.0
Net	42	35.9	3	2.6	72	61.5
Hook and line	32	27.4	8	1.7	83	70.9
Canoe	39	33.3	6	5.1	72	61.5
Aquaculture						
Pond	0	0	0	0	117	100
Pumping machine	0	0	0	0	117	100
Water quality kits	0	0	0	0	117	100
Well	2	1.7	3	2.6	112	95.7
Borehole	0	0	4	3.4	113	96.6
Generator	5	4.3	0	0	112	95.7
Processing						
Grinding machine	9	7.7	3	2.6	105	89.7

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Banda	41	35.0	6	5.1	70	59.8
Modern kiln	0	0	0	0	117	100
Farming						
Seeds	42	35.9	22	18.8	53	45.3
Fertilizer	4	3.4	18	15.4	95	81.2
Pesticide	1	0.9	19	16.2	97	82.9
Camel/Bull	13	11.1	11	9.4	93	79.5
Tractor	0	0	19	16.2	98	83.8
Sowing machine	0	0	0	0	117	100
Communication						
Mobile phone	33	28.2	2	1.7	82	70.1
Radio	14	12.0	2	1.7	101	86.3
Television	3	2.6	0	0	114	97.4
Decoder	0	0	0	0	117	100
VCD	1	0.9	0	0	116	99.1
Viewing Centre	1	0.9	0	0	116	99.1
Transportation and sales building						
Motor cycle	51	43.6	9	3.4	62	53.0
Motor vehicle	1	0.9	1	0.9	115	98.3
Bicycle	14	12.0	10	2.6	100	85.5
Shop	6	5.1	0	0	111	94.4
Restaurant	0	0	2	1.7	115	98.3

Source: Field Survey, (2020)

CONCLUSION AND RECOMMENDATION

The study showed that members of the communities were active members of socio group and also makes use of physical asset available in the communities. The study recommended that socio group should be further encouraged in the communities which will stand as a platform where voices of communities will be heard on a particular subject matter.

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BENEFITS DERIVED FROM AQUACULTURE TRAINING BY FISH FARMERS IN YENAGOA LOCAL GOVERNMENT AREA OF BAYELSA STATE, NIGERIA

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ABSTRACT

The study investigated the benefits derived from aquaculture training by Fish Farmers in the Yenogoa Local Government Area of Bayelsa State. Kobo collect tool was used to obtain data from 40 fish farmers who were selected using snow-balling sampling techniques. Data obtained were analyzed using descriptive (frequency counts, percentages, mean and standard deviation. ANOVA was used as the inferential tool. The mean age of the respondents was 49.6 ± 9.237 years, with 92.5% being males. The majority (97.5%) of the respondents were married with a mean household size of 9.6 ± 4.903 . Almost half (47.5%) of the respondents had 19 years of formal education with NCE/OND having the highest level of education. The mean farming experience was 7.46 ± 3.719 years. The majority (87.5%) of the respondents' purpose for fish farming was income generation and household consumption. Over half (60%) of the respondents owned their farms personally. Above half (62.5%) of the respondents had 6-10 ponds. The major benefits were fish seed production and fish feed production having a mean of 1.70 and 1.30 respectively. The major constraints were poor accessibility to extension agents and a lack of need-based programmes during training. A significant relationship exists between benefits derived from the respondents and farmers' age, household size, years of education, highest level of education, years of fishing experience and the number of ponds while the marital status of the respondents had no significant relationship with benefits derived from aquaculture training. It is recommended that fish farmers should have access to extension agents and the focus should be more on need-based programmes for fish farmers during the training.

Keywords: Benefits, Aquaculture training, Fish Farmers.

INTRODUCTION

Fish farming generates employment directly and indirectly in terms of people employed in the production of fishing output and other related businesses. It also generates income for all categories of people involved in fish farming and this contribute to national income (William *et al.*, 2010; Ifejika *et al.*, 2013 and Adefalu *et al.*, 2013).

Fish farming dated back to the 1950s in Nigeria (Olaoye *et al.*, 2014). However, Nigeria has been one of the largest importers of fish in the developing world, importing over 600,000 metric tons annually (Nwosu and Onyeneke, 2013). Ofuokwu *et al.*, 2008 and Hempel 2020 have however described the training as a viable tool for enhancing the capacity of fish farmers to over the production challenges that have hindered the sector from steady growth. However, training is a process of acquiring new skills, attitudes and knowledge in the kind of education referred to in the context of not preparing for entry into a vocation or improving one's productivity in an organization or entrepreneur. Training plays an important role in the advancement of human performance in a given situation (Sajeev *et al.*, 2012). Farmers' training is directed towards improving their job efficiency in farming. This kind of training is not for knowing more but for behaving differently (Umunna *et al.*, 2019). Training can also be said to be a concept which performs the therapeutic function of shaping knowledge, skill and attitude that is required for the effective performance of duties and or assignments (Adisa and Okunade, 2005). The essence of training is aimed at communicating information, knowledge and skills, replacing old attitudes with new ones, exchanging opinions and experience, and removing doubt and difficulties (Raab *et al.*, 1991).

There are several challenges confronting fish farming in Nigeria. However, extension services efforts toward fish production including how fish farmers can benefit from aquaculture training if truly fish farmers take to use of the knowledge impacted during the training which will help boost production at large. Based on this, this study was mainly aimed at considering the following objectives; (i) identification of socio-economic characteristics of the fish farmers, (ii) investigation of benefits derived by fish farmers from aquaculture training programmes and (iii) identification of important constraints to be considered when organizing aquaculture training programmes.

HYPOTHESIS OF THE STUDY

H₀: There is no significant relationship between the socio-economic characteristics of the respondents and the benefits derived from aquaculture training

H₁: There is a significant relationship between the socio-economic characteristics of the respondents and the benefits derived from aquaculture training.

MATERIALS AND METHODS

Study Area, Sample Procedure and Sample size

Yenagoa is a Local Government Area and Capital City of Bayelsa State, Southern Nigeria. It is located in the Southern part of Nigeria and with coordinates 4° 55' 29" N, 6° 15' 51" E. The Local Government Area has a land area of 706 km² and a population of 352,285 at the 2006 census. Ijaw form the majority of the State. Yenagoa is situated in an area of swamps and mangroves. Yenagoa experiences equatorial with climate two distinct seasons which are wet and dry seasons. It has an average rainfall of between 3,000 -3,500 mm. It has an average daily temperature between 26°C and 28°C and relative humidity of 70-90% during the wet season and 50% during the dry season. The population of the study were fish farmers in Yenagoa Local Government Area. A sample size of 40 fish farmers was selected from the population using a snowball-sampling technique. This was used because there was no record to show the list of fish farmers in the Yenagoa Local Government Area. However, those who are fish farmers know themselves.

METHOD OF DATA COLLECTION: Data collected for the study was obtained from a digitalized well-structured questionnaire with Computer Aided Personal Interview (CAPI) which is an open-source application installed on Android phones. CAPI allows for the recording of interview responses on handheld devices such as tablets or smartphones, rather than paper questionnaires.

Measurement of variables and data analysis: The dependent variable of the study is benefits derived from fish farmers and this was measured by subjecting the respondents to 10 items on a rating scale of highly beneficial = 2, beneficial = 1 and not at all = 0. Constraints to be considered during the training programme were also measured by subjecting the respondents to 10 items on a rating scale of highly severe = 2, severe = 1 and not severe = 0. The benefits derived and constraints to be considered were measured in the order of ranking through the weighted mean that was calculated by multiplying the point on the scale by the frequency and summing it up. The sum is therefore divided by the total number of respondents to get the Weighted Mean Index (WMI) for both benefits derived and constraints to be considered during training programmes by respondents. The method of data analysis involved the use of descriptive statistics such as frequency counts, percentages, mean and standard deviation were used to describe the socio-economic characteristics of respondents. ANOVA was used to test the relationship between benefits derived by fish farmers from aquaculture training and socio-economic characteristics.

RESULTS AND DISCUSSIONS

Socio-Economic Characteristics of Respondents

The distribution of socioeconomic characteristics of the respondents is shown in Table 1. The majority (92.50%) of the respondents were male while 7.5% were females. This shows that males were mostly involved in fish farming than females. This finding agrees with Ogunleye, Ojo and Oyewo (2015) that males

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were mostly involved in fish farming than females. The mean age of the respondents was 49.6 ± 9.237 years. This is in conformity with Ajala, Kolawole and Owolabi (2016). The majority (97.5%) of the respondents were married with a mean household size of 9.6 ± 4.903 . Almost half (47.5%) of the respondents had 19 years of formal education and NCE/OND has their highest level of education with a mean farming experience of 7.46 ± 3.719 years. The years of fish farmers are of close range to that of Famuwagun (2015). The majority (87.5%) of the respondents' purpose of fish farming was for income generation and household consumption. Over half (60%) of the respondents owned their farms personally. Above half (62.5%) of the respondents had 6-10 ponds.

Table1: Distribution of the Respondents according to their socio-economic characteristics.

Characteristics	Frequency	Percentages	Mean	Standard Deviation
Sex				
Male	37	92.5		
Female	3	7.5		
Total	40	100		
Age				
31-40	5	12.5		
41-50	18	45.0	49.60	9.234
51-60	11	27.5		
61-70	6	15.0		
Total	40	100		
Household Size				
1-5	7	17.5		
6-10	19	47.5		
11-15	9	22.5	9.60	4.903
16-20	4	10.0		
21-25	1	2.5		
Total	40	100		
Marital Status				
Married	39	97.5		
Single	1	2.5	1.975	0.158
Total	40	100		
Years of Education				
14-15	19	47.5		
16-17	15	37.5	15.85	1.626
18-19	6	15.0		
Total	40	100		
Years of Educational Level				
M.Sc.	6	15.0		
B.Sc./H.N.D.	15	37.5	1.525	0.505
N.C.E/O.N.D	19	47.5		
Total	40	100		
Year of Fishing Experience				
1-5	11	27.5		
6-10	20	50.0	7.46	3.719
11-15	8	20.0		
16-20	1	2.5		
Total	40	100		
Purpose of fish farming				
Income and Household Consumption	35	87.5		
Household Consumption and Festivity/Ceremony	5	12.5	1.125	0.334
Total	40	100		
Land Ownership				

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Purchase	9	22.5		
Renting	1	2.5		
Family Land	6	15.0	1.40	0.496
Personally Owned	24	60.0		
Total	40	100		
Numbers of Ponds				
1-5	12	30.0		
6-10	25	62.5	6.98	3.166
11-15	3	7.5		
Total	40	100		

Source: Field Survey, 2022

Benefits Derived by Fish Farmers from Aquaculture Training

The benefits derived as perceived by the respondents are shown in Table 2. The majority (77.5%) of the respondents highly benefited from aquaculture training on fish seed production while 15% of the respondents benefited from training on fish seed production. Also, 42.5% of the respondents highly benefited from fish feed production while 45.2% benefited from fish feed production. The given Table further depicts that 35% of the respondents highly benefited from training in fish processing and value addition while 45% of the respondents benefited from training in fish processing and value addition. 40% of the respondents highly benefited from training in identification and selection of culturable species while 35% of the respondents highly benefited from training on identification and selection of culturable species. Likewise, Table 2 shows that 35% of the respondents highly benefited from extension methods in aquaculture while 17.5% benefited from extension methods in aquaculture. This implies that the aquaculture training was highly beneficial. This is because they fall between the range of 1-5 according to the order of ranking while the remaining, that is pond management, pond construction, site selection, the economics of aquaculture, record keeping and data collection were of low benefits.

Table 2: Distribution of respondents according to benefits derived from aquaculture trainings.

Aquaculture Training	Level of Benefits Derived from Aquaculture Trainings			Mean	Rank
	Highly Beneficial (2)	Beneficial (1)	Not At All (0)		
Fish Seed Production	31 (77.5)	6 (15.0)	3 (7.5)	1.70	1
Fish Feed Production	17 (42.5)	18 (45.0)	5 (12.5)	1.30	2
Fish Processing and Value Addition	14 (35.0)	18 (45.0)	8 (20.0)	1.20	3
Identification and Selection of Culturable Specie	16 (40.0)	14 (35.0)	10 (25.0)	1.15	4
Extension Methods in Aquaculture	14 (35.0)	7 (17.5)	19 (47.5)	0.88	5
Pond Management	7 (17.5)	18 (45.0)	15 (37.5)	0.80	6
Pond Construction	8 (20.0)	15 (37.5)	17 (42.5)	0.78	7
Site Selection	6 (15.0)	15 (37.5)	19 (47.5)	0.68	8
Economics of Aquaculture	4 (10.0)	16 (20.0)	20 (50.0)	0.60	9
Record Keeping and Data Collection	2 (5.0)	20 (50.0)	18 (45.0)	0.55	10

Source: Field Survey, 2022. Figures in parenthesis are percentages

Constraints Faced by Fish Farmers during Aquaculture Training.

The constraints faced by fish farmers are depicted in Table 3. The majority (80%) and 7.5% had highly severe and severe constraints from poor accessibility to extension agents respectively. Also, 70% and 22.5% had highly severe and severe constraints from a lack of need-based programmes during training respectively. The Table further depicts that 65% and 25% of the respondents had highly severe and severe constraints on lack of detailed information in manual materials respectively. Over half (60%) and 32.5% of the respondents

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had highly severe and severe constraints from lack of financial support respectively. Very few (12.5%) and 35% of the respondents had highly severe and severe constraints towards ineffective communication respectively. Furthermore, the Table shows that 15% and 20% had highly severe and severe constraints towards training not suitable for their farms respectively. 17.5% and 12.5% of the respondents had highly severe and severe constraints towards lack of technological know-how respectively. However, 10% and 22.5% of the respondents had highly severe and severe constraints towards lack of social media respectively. Also, from the table, 10% and 15% of the respondents had highly severe and severe constraints toward the complexity of information respectively. In the Table, 7.5% and 12.5% of the respondents had highly severe and severe constraints towards illiteracy respectively. The mean of the constraints was calculated where accessibility had the highest mean of 1 was .68 and followed by lack of need-based programmes during training. The constraints were finally ranked from 1–10.

Table 3: Distribution of respondents according to the Constraints faced during Aquaculture Training

Constraints Faced by Fish Farmers	Level of Constraints Faced by Fish Farmers during Training				
	Highly Severe (2)	Severe (1)	Not Severe (0)	Mean	Rank
Poor accessibility to extension agents	32 (80.0)	3 (7.5)	5 (12.5)	1.68	1
Lack of need-based programmes during training	28 (70.0)	9 (22.5)	3 (7.5)	1.63	2
Lack of detailed information in manual materials	26 (65.0)	10 (25.0)	4 (10.0)	1.55	3
Lack of Financial support	24 (60.0)	13 (32.5)	3 (7.5)	1.50	4
Ineffective Communication	5 (12.5)	14 (35.0)	21 (52.5)	0.60	5
Training is not suitable for my farm	6 (15.0)	8 (20.0)	26 (65.0)	0.50	6
Lack of Technological-know-how	7 (17.5)	5 (12.5)	28 (70.0)	0.48	7
Lack of Mass Media Exposure	4 (10.0)	9 (22.5)	27 (67.5)	0.43	8
Complexity of Information	4 (10.0)	6 (15.0)	30 (75.0)	0.35	9

Source: Field Survey, 2022. Figures in parenthesis are percentages

Results of hypothesis: Socio-economic factors that were significant from the result in Table 4 include age (0.00), household size (0.00), years of education (0.00), the highest level of education (0.00) years of fishing experience (0.00), attendance of training (0.00) and numbers of ponds (0.00) were the major factors that determine the benefits derived by fish farmers.

Table 4: ANOVA showing the relationship between benefits derived by fish farmers in aquaculture training and socio-economic characteristics

		ANOVA				
		Sum of Squares	df	Mean Square	F	Sig.
Age	Between Groups	3143.633	18	174.646	19.936	.000
	Within Groups	183.967	21	8.760		
	Total	3327.600	39			
Household Size	Between Groups	883.567	18	49.087	19.078	.000
	Within Groups	54.033	21	2.573		
	Total	937.600	39			
Marital Status	Between Groups	.475	18	.026	1.108	.407
	Within Groups	.500	21	.024		
	Total	.975	39			
Years of Education	Between Groups	92.900	18	5.161	10.626	.000
	Within Groups	10.200	21	.486		

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	Total	103.100	39			
Highest Level of Education	Between Groups	9.308	18	.517	16.290	.000
	Within Groups	.667	21	.032		
	Total	9.975	39			
Years of Fishing Experience	Between Groups	389.826	18	21.657	3.188	.007
	Within Groups	135.867	20	6.793		
	Total	525.692	38			
Attendance of Trainings	Between Groups	8.300	18	.461	12.104	.000
	Within Groups	.800	21	.038		
	Total	9.100	39			
Number of Ponds	Between Groups	325.008	18	18.056	5.748	.000
	Within Groups	65.967	21	3.141		
	Total	390.975	39			

CONCLUSION AND RECOMMENDATIONS

Based on the empirical finding of the study it is concluded that fish farmers are educated. This might be due to the metropolitan nature of the study area and being the capital of the State and its implication is that they will want to learn new things regarding aquaculture training. They also have quite a number of ponds. The level of education should be considered when organizing aquaculture training. The organizers should consider constraints such as poor access to extension agents and lack of need-based programmes during aquaculture training to enable the fish farmers to get information and meet them at the point of their needs.

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The Economic Effect of Boko Haram Insurgency on Fish Marketing in Maiduguri, Borno State. : A case study of Three Major Fish markets in Maiduguri Metropolitan Council.

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ABSTRACT

This study analysed the effects of insurgency on fish marketing in Maiduguri metropolis local government of Borno state, Nigeria. The data used for this research are mainly primary data, which were collected using structured questionnaire and were analysed using descriptive statistics such as tables, frequency, percentage and gross margin for cost and return. The result of socio-economic characteristics of participants in fish marketing showed that male had highest percentage of (83.3%) The study showed that highest percentage of (76%) were married, (18.3%) were single and only 1 respondent was widow. The findings on educational level revealed that 31 respondents with (51.6%) attained Qur'anic School, and most of the respondents had marketing experience of 20 years and above with the percentage of (43.3%). The most effective constraints examined are Lack of capital with (76.6%) very severe, high price of fish with (65%) very severe, Imposition of curfew with (71.6%) severe, Transportation cost with (48.3%) severe and Scarcity of fish with (45%) severe. It was recommended that concerted effort should be made by all stakeholders in revamping the fish marketing to return and spin-off the economy of the state.

Keywords: Boko Haram, insurgency, fish marketing, Economy, Borno state

INTRODUCTION

Borno State, on the international front is bordered by three countries namely: Niger, Tchad and Cameroon. These countries constituted major trading partner to the State and Nigeria in general (Fausat and Tukur, 2015). Substantial amount of the State's fish and fish product requirement comes from Tchad and Cameroon. Borno State also provides ready market for her neighboring countries in terms of agricultural produce. Thus, there is a buoyant cross-border trade between the State and her international neighbors. On the local front, the state is bordered by three states namely, Adamawa, Gombe and Yobe. Internally, the State is composed of 27 local government areas and each of this Local Government Areas (LGA) has peculiar market day's arrangement with distinct traded products. Borno state is the largest market for fish in West Africa and has great potential to increase her fish production. Fish products are highly traded and global fish trade has been

increasing very rapidly in recent decades with an estimated 45% of the world catch now traded internationally (The FishSite, 2015).

The fish and fish product trading activities in fish market in Maiduguri Local Government Area of Borno state is a lucrative economic activity that provides substantial livelihoods and employments to many fish traders in the area. This has once created increased trans boundary trade between Borno, Niger, Chad, and Cameroon. Borno experienced multiple and severe attacks of Boko Haram insurgency which appear to have unmeasurably affected fish production and supply in the area. It has been recorded that the insurgent attacks that led to increase in the displacement of fish traders which creates disruption in supply, distribution and high prices of fish and causes displacement of fish marketers.

Marketing is an activity which stimulates further production and if efficiently done, both the producer and consumer get satisfied in the sense that the former gets a sufficiently remunerative price for the product to continue to produce, while the latter gets it at an affordable price that stimulates continue consumption. Marketing, therefore, encompasses all business activities associated with the transfer of a product from the producers to the consumers (Mafimisebi, 2011). According to Otte *et al* (2012) Boko Haram insurgency attacks has more adverse effects on economic and social development in the afflicted areas than some ancillary aspects which many studies had focused (Tukur *et al.*, 2015). The repercussion of the dreadful attacks perpetrated by this insurgent in Maiduguri, Borno State, has caused major economic problem and adversely affects animal market (Mohammed *et al.*, 2020). Despite the established facts that there is high demand for fish and its products, and the supply is hampered, however, the extent the effect of Boko Haram insurgency on the supply of fish in Maiduguri has not only adequately appraised but opens a serious concern. Increase of insurgency in the study area has seriously affected the livelihoods of fish marketers such that many people including businessmen are fleeing to more peaceful environment in other parts of the country. More so, the prices of fish products have been increasing astronomically following the drastic fall in the supply of the products from market to the other parts of Nigeria where they are greatly consumed (Abigail, 2014). This study, therefore aimed at analyzing the economic effects Boko Haram insurgency in Borno state: A Case Study of Maiduguri Local Governments Area.

Materials and Methods

Study Area

The study area is Maiduguri Metropolis, the capital of Borno State of Nigeria. Which lies within latitudes 10–140N and longitude 110301E, and 140451E, and it occupies a total landmass of 50,778sq km (MLSM, 2008). It shares boundaries with Konduga Local Government Area to the North and Northwest and Jere Local Government Area to the South Maiduguri Metropolis has an estimated population of 521,492 people out of which 290,449 were male while 231,043 were female (NPC, 2006). Majority of the inhabitants are farmers, fisher men, traders, or civil servants. The major ethnic group is Kanuri, others include Shuwa Arabs, Babur/Bura, Marghi, Maffa, Mandara, Fulani and Hausa, and many immigrant settlers from within and outside Nigeria, and English is the official language (BOSADP, 2007). Major crops produced in the area include millet, sorghum, maize, and groundnuts (Tijjani *et al.*, 2016).

Sampling Procedure

Simple stratified random sampling techniques were used. Respondents were choosed randomly among fish marketers in different fish markets in Maiduguri. Simple random sampling of 15 marketers and 5 transporters will be carried out, making the total of 20 respondents each in Gamboru custom area fish market, Tashan Baga fish market and Maiduguri Monday market.

Source of Data

Both primary and secondary information were used for the purpose of this research. The primary data was collected through the administration of structured questionnaire. Secondary data was obtained from unpublished student project, journals and publications, book, and workshop proceedings.

Data Analysis

The analytical techniques such as descriptive statistics, gross margin, frequencies, percentages, tables, and distribution were used.

The gross margin analysis will be used.

Gross margin is given as: $GM = GR - TVC$

Where, GM = Gross Margin (in Naira)\carton of fish

GR = Gross Revenue(in Naira)\carton of fish

TVC = Total Variable Cost(Naira)



Plate 1.0: Collection of Data in Fish Markets

RESULTS AND DISCUSSION

Table 1 presents socio-economic characteristics to the respondents.

Distribution of respondents based on gender is very important in order to know which category was largely involved in the fish marketing in Maiduguri metropolis which revealed that males were (83.3%), while females constitute only (16.7%). Mohammed *et al*, (2011), revealed that the high percentage of the male fish seller in the enterprise could be attributed to hard management practice having much labor demanding and viewed as masculine works. The results showed that the respondents are of various age groups. Majority (36.6%) falls within the age of 30-39 years. This indicates that most of the respondents are in their youthful active productive age.

The results indicate that the majority (76%) of the fish sellers were married, only (18.3%) were single. This implies that the majority of the marketers have family responsibilities for providing foods to their families, they tend to be motivated and more involve in fish marketing so as to enable them meet their family needs. The result shows that (51.6%) of the respondent does not go to formal education at all, but they attended Qur'anic Education. According to Ali (2008) 10% of the marketers have not had any formal education, 26.67% had attended primary school and 28.3%, had attended secondary school, 3.3% had attended a tertiary institution, and 31.67% had attended Qur'anic schools. It can be concluded that most of the marketers did not have formal education, which seemed to be the major reason of slow rate of adoption of innovation in fish marketing. This implies that, the most important in the respondents is their experience and not really

education level. The result revealed that, the majority of the respondent had experience of 20 years and above with the percentage of 43.3%. This influences that the sellers understand the nature of the market and associated with price as well as socio-economics changes and policies and factor that affecting the marketing and its channel.

This study analyzed the effects of insurgency on fish marketing in Maiduguri metropolis, Borno state, Nigeria, the specific objective of the study were to identify the socio-economic characteristics of participants in the market, cost and return of marketing fish, before the insurgency, as well as to examine the constraint to fish marketing during the year of insurgency.

The data used for this research are mainly primary data, which were collected using structured questionnaire, were analyzed using descriptive statistics such as tables, frequency, percentage and gross margin for cost and return.

The result of socio-economic characteristics of participants in fish marketing showed that male had highest percentage of (83.3%) and fall within the age group of 30-39 years. The study show that majorities (76%) were married, 18.3% were single and only 1 respondent was widow.

Educational level revealed that 31 respondents (51.6%) attained Qur'anic School, and the majority of the respondents had marketing experience of 20 years and above with the percentage of 43.3% similar findings obtained by Gaya *et al.* (2006) which revealed that the educational level or background of the fish marketers showed that only few attended literacy class and the implication of this was that adoption of new technology might be slow.

The major constraints faced by fish marketers in Maiduguri due to insurgency are; high cost of fish and Cost of transportation similar findings with Akinola (2015) which examined the similar severe constraints of high cost of fish and high transportation cost with (48% reported as severe). The other constraints are Lack of good storage facilities, Lack of good processing facilities, Lack of capital, Low supply of fish (fish scarcity) and Imposition of curfew. Ali (2008) shows the different findings which reported the most problems faced by the marketers was Spoilage during storage was ranked first with (30%).

According to Bada (2010) frozen fish market in Ibadan, Oyo state, the major constraints faced by the frozen fish marketers is power supply, followed by storage cost, spoilage, transport cost, finance and lastly market levies.

Table 1: Socio-economic characteristics of respondents

Variation distribution	Frequency	Percentage (%)
Sex:		
Male	53	83.3
Female	7	16.7
Total	60	100
Age:		
Lessthan 14yrs	0	0.0
15-29yrs	17	28.3
30-39yrs	22	36.6
40-49yrs	13	21.6
Above 50yrs	8	13.3
Total	60	100
Marital Status:		
Single	11	18.3
Married	46	76.6
Divorced	2	3.3
Widow	1	1.66
Total	60	100

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Level of Education:

Qur'anic Education	31	51.6
Adult Education	2	3.3
Primary Education	14	23.3
Secondary Education	11	18.3
Tertiary Education	2	3.3
Total	60	100

Year of experience in fish marketing:

Less than 5 years	12	20
6-10 years	6	10
11-15 years	6	10
16-20 years	10	16.6
Above 20 years	26	43.3
Total	60	100

Source: Field survey, 2020.

Constraints to fish marketing due to insurgency

The following are the constraints faced by the fish marketing during the year of insurgency.

Table 2: Lack of apital:

Constraints level	Frequency	Percentage(%)	Ranking
Severe	14	23.3	2 nd
Very severe	46	76.6	1 st
Non Severe	0	0	3 rd

Table 3: Lack of proper storage:

Constraints level	Frequency	Percentage(%)	Ranking
Severe	21	35	2 nd
Very severe	14	23.3	3 rd
Non Severe	25	41.6	1 st

Table 4: Imposition of curfew:

Constraints level	Frequency	Percentage(%)	Ranking
Severe	43	71.6	1 st
Very severe	5	8.3	3 rd
Non Severe	12	20	2 nd

Table 5: Transportation:

Constraints level	Frequency	Percentage (%)	Ranking
Severe	29	48.3	1 st
Very severe	6	10	3 rd
Non Severe	25	41.6	2 nd

Table 6: High price of fish:

Constraints level	Frequency	Percentage(%)	Ranking
Severe	20	33.3	2 nd
Very severe	39	65	1 st
Non Severe	1	1.7	3 rd

Table 7: Scarcity of fish:

Constraints level	Frequency	Percentage(%)	Ranking
Severe	27	45	1 st
Very severe	25	41.6	2 nd
Non Severe	8	13.3	3 rd

CONCLUSION

The result of the study showed that, fish marketing is highly profitable before the insurgency but the rate of the profit became minimal due to Boko Haram insurgency. Selling fish is a profitable business venture which greatly contributes to the humanity, food security and livelihood of both male and female in Maiduguri.

RECOMMENDATION

In order to increase in both quality and quantity of fish marketing among the fish marketers in Maiduguri, the following recommendations were made:

1. Marketers should increase fish production in order to have more income and increase in market efficiency, high productivity and maximum profitability.
2. Provision of smooth running and effective enterprise in Maiduguri must be considered for easy transportation and products availability.
3. Government should try to figure out and solve the problems were facing by both buyers and sellers in fish marketing activities in Maiduguri.
4. Government should provide credit facility to the targeted fish marketers by agricultural loans, government empowerment fund, and initiatives by governmental and non-governmental organization.
5. Government should provide improved and efficient storage facilities for fish sellers for fish storage.
6. The extension agents should be deployed to assist the marketers to form cooperatives society.
7. Government should also improve the marketing activities and quality assurance

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ANNUAL STUDY OF ZOOPLANKTON COMPOSITION AND WATER QUALITY OF KISRA RESERVOIR IN NIFFR, NEW BUSSA, NIGER STATE

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ABSTRACT

Environmental factor, water quality and seasonal variation plays an important role in the lives of aquatic organisms in freshwater. This research aims at providing a baseline study as it regards Zooplankton population in kisra reservoir across both wet and dry seasons. The samples were collected monthly (May 2021 to February 2022) for both physicochemical and Zooplankton study and were analyzed using standard analytical techniques. The data were analyzed using Independent T-Test. The result showed that D.O, turbidity and depth were significantly higher in wet season than in dry season, this may be due to more water flooding into the reservoir, less evaporation in wet season and the settling effect of the suspended materials while pH and Alkalinity were significantly higher in dry season than in wet season ($P < 0.05$), this may be due to high evaporation in dry season. There was no significant difference in B.O.D, Water temperature and Water Conductivity ($P > 0.05$). Copepoda was the most dominant group in wet season (59%) followed by Cladocera (27%) then Rotifera (14%), this could be as a result of the cool weather condition which supports the growth and population of Copepoda in the wet season. Rotifera were the most dominant in dry season (68%), followed by Copepoda (16%) and Cladocera (16%) which could be due to the harsh weather condition that support Rotifers population in the dry season. Although in terms of species diversity, Rotifera has more species than any other group in both wet and dry season. Water quality and seasonal variation affect the composition of Zooplankton in both wet and dry season.

KEYWORDS: Water quality, Zooplankton, Reservoir, Season

INTRODUCTION

Water quality assessment generally involves analysis of physico-chemical, biological and microbiological parameters and reflects on abiotic and biotic status of the ecosystem (Rajagopal *et al.*, 2011). Surface water reservoirs are considered as one of the planet's most important freshwater resources and provide innumerable benefits. Reservoirs are stagnant surface water bodies, receive and stores rain fall water. Zooplanktons are microscopic aquatic life forms having little or no resistance to currents and are free floating or suspended in open or pelagic waters (Thorp and Covich, 1991). While some forms of zooplankton move by vertical migration, their horizontal position is mostly determined by current movements of the water they inhabit (Balcer *et al.*, 1984). Planktonic animals deploy various ecological strategies, they are characterized by phylogenetic distinctness and can be dispersed passively across large areas, which is why they are often used to test ecological theories and develop ecosystem (prognostic) models (Chou *et al.*, 2011; Du X, 2015; Feitosa 2019; Kruk and Pature 2020; Kruk *et al.*, 2020; Kruk *et al.*, 2021). The structure of plankton communities is determined by abiotic environmental conditions (filters), and it is characterized by a specific species composition and functional traits (Oh 2017; Sodre and Bozelli, 2019; Simoes 2020; Gozdziejewska, *et al.*, 2021). This provides a basis for forming interspecific relationships, which in the case of zooplankton consist mainly of competitive exclusion and predation (Hart 1988; Gliwicz and Pijanowska 1989). The structure of the interactions between the abiotic environment and the features of zooplankton assemblages is frequently analysed to obtain reliable information about the current status of aquatic ecosystems and to forecast future changes. They are being considered as water quality indicators in aquatic environment many years ago. Some species flourish in highly eutrophic water while others are very sensitive to organic or chemical wastes.

Different biota including zooplankton composes lotic water communities. Zooplanktons are minute invertebrates which constitute the productive base of freshwater ecosystem. Zooplanktons are diverse and are affected by several factors. Zooplankton density, composition, distribution and abundance were principally influenced by season and water quality parameters. Thus, zooplankton abundance and distribution were widely associated with environmental conditions (Hassan *et al.*, 2019). The distribution of zooplankton communities depends on many factors, some of which are change of climatic conditions, physico-chemical parameters and vegetation cover. Therefore, present investigation attempts to present benchmark information on zooplankton abundance, seasonality and effect of physicochemical parameters on zooplankton species in Kisra Reservoir, located at Niffr estate, along Hatchery complex, New Bussa, Niger State.

MATERIALS AND METHOD

Study Area

The study was carried out in kisra reservoir located within kainji lake region at Niffr estate, hatchery, New Bussa, Niger State. The reservoir constructed in 2008 is located at latitude N9°52'44" and longitude E4°32'23". Its rainy season is from April\May to October and dry season from November to March.

Sampling for Physicochemical Parameters

The sampling was carried out monthly (from May 2020 to February 2021). Samples were collected in the morning using water sampling bottle between 09:30am to 10:30am and 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.

Table 1: Physico-chemical parameters measured and Instruments Used

PARAMETER	METHODOLOGY
pH	pH Meter
Conductivity	Conductivity Meter (Model DA-1, CODE 1918)
Alkalinity	Titration
Depth	Calibrated secchi disc
Water temperature	Thermometer
Turbidity	Calibrated secchi disc
D.O	Azide Modification
B.O.D	5days test

NB: D.O- Dissolved Oxygen, B.O.D- Biological Oxygen Demand

Data Analysis

Data collected were statistically analyzed using T-test

Sampling for Zooplankton

Zooplankton samples were collected using silk bolting zooplankton net with mesh size of 50µm and mouth diameter of 12cm. Samples were preserved in 10% formalin and were allowed to stand undisturbed for over 24 hours on a flat surface to allow organisms settle. Thereafter, the sample volume was reduced to about 10ml by siphoning with a pipette fitted with a flexible rubber tubing of 5mm diameter. The tip of the pipette was also fitted with a 50µm mesh size zooplankton net to prevent accidental loss of organisms during siphoning. This was done once in a month across both the wet and dry season.

RESULTS AND DISCUSSION

Table 2 shows the mean of physico-chemical parameters of kisra reservoir in both wet and Dry Seasons. Fig. 1: shows the percentage composition of Zooplankton in wet Season. Fig. 2: shows the percentage Composition of Zooplankton in Dry Season.

Table 2: Seasonal mean of Physico-chemical parameters (wet and dry Seasons)

PARAMETERS	WET SEASON MEAN±SD	DRY SEASON MEAN±SD
pH	7.01±0.05 ^a	7.20±0.07 ^b
B.O.D (mg/l)	5.20±1.30 ^a	4.28±2023 ^a
Water Tempt. (°C)	28.13±1.90 ^a	29.65±0.50 ^a
D.O. (mg/l)	14.33±1.57 ^a	5.80±1.17 ^b

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Turbidity (m)	0.39±0.03 ^a	0.16±0.12 ^b
Alkalinity (mg/l)	10.00±0.00 ^a	29.17±14.29 ^b
Conductivity (µs/cm)	53.50±6.50 ^a	68.33±28.79 ^a
Depth (m)	1.16±0.28 ^a	0.40±0.18 ^b

NB: Mean value with the same superscript shows no significant difference while different Superscript shows a significant difference.

Table 3: Zooplankton composition Kisra Reservoir during the wet season

Rotifera	Cladocera	Copepoda
<i>Asplanchna</i> sp	<i>Diaphanosoma exisum</i>	<i>Cyclopoid</i> sp
<i>Pythgra</i>	<i>Moina</i> sp	<i>Copepodites</i>
<i>Trichocerca cylindrical</i>	<i>Nauplii</i>	
<i>Brachionus calyciflorus</i>		
<i>Brachionus fulcatus</i>		
<i>Brachionus angularis</i>		
<i>Lecane</i> sp		
<i>Polyarthra</i> sp		
<i>Filinia opoliensis</i>		
<i>Keratella tropica</i>		
<i>Syncheata</i> sp		

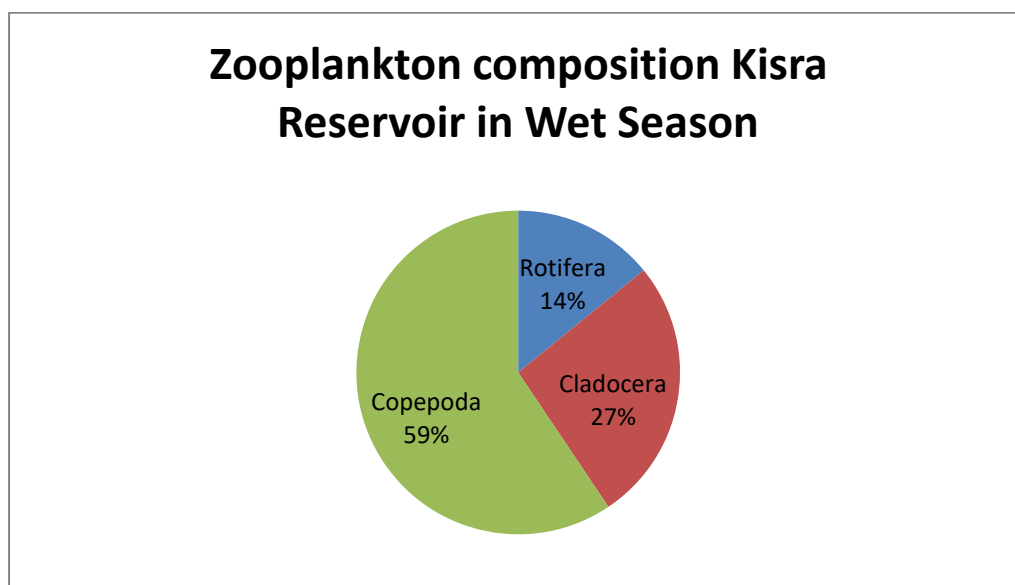


Fig.1: Percentage composition of Zooplankton in wet Season

Table 4: Zooplankton composition Kisra Reservoir during the dry season

Rotifera	Cladocera	Copepoda
<i>Pythgra</i>	<i>Diaphanosoma exisum</i>	<i>Cyclopoid</i> sp
<i>Trichocerca cylindrica</i>	<i>Moina</i> sp	<i>Copepodites</i>
<i>Brachionus calyciflorus</i>	<i>Nauplii</i>	
<i>Brachionus angularis</i>		
<i>Lecane</i> sp		
<i>Brachionus fulcatus</i>		
<i>Filinia opoliensis</i>		
<i>Keratella tropica</i>		

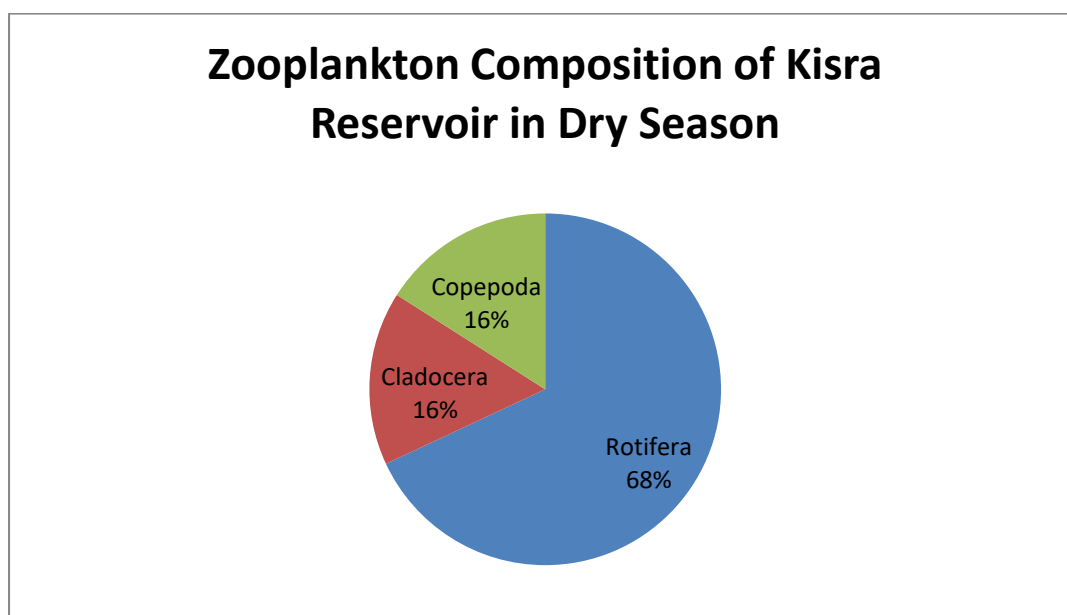


Fig. 2: Percentage Composition of Zooplankton in dry Season

Table 2: The result shows a significant difference ($P < 0.05$) in pH, DO, Turbidity, Alkalinity and Depth. pH in dry season (7.20 ± 0.07) was significantly higher than wet season (7.01 ± 0.05), Alkalinity was significantly higher in dry season (29.17 ± 14.29) than in wet season (10.00 ± 0.00), D.O. was significantly higher in wet season (14.33 ± 1.57) than in dry season (5.80 ± 1.17), Turbidity was significantly higher in wet season (0.39 ± 0.03) than in dry season (0.16 ± 0.12) and depth was significantly higher in wet season (1.16 ± 0.28) than in dry season (0.40 ± 0.18) and there was no significant difference ($P > 0.05$) in B.O.D, water temperature and water conductivity in both wet and dry season.

Fig 1: This shows percentage composition of zooplankton in wet season. Copepoda (59.41%) dominate the population, mostly *Copepodites*, in wet season followed by Cladocera (26.47%), mostly *nauplii* and Rotifera (14.12%), mostly *lecanes* sp.

Fig 2: This shows zooplankton composition in kisra reservoir in Dry season. Rotifers (68.04%) dominate the population in dry season, followed by copepoda (16%) and cladocera (16%).

The significant difference pH is attributed to as a result of increase in algae population by their photosynthetic activity during the dry seasons which lower during the wet season. D.O., Turbidity and depth were significantly higher in wet season because in rainy season more water flows into the reservoir and low evaporation, dirty materials which hinders D.O. was less in wet season, presence of high rain water, surface run offs, the settling effects of the suspended materials and less human and animal activities around the reservoir all contributed to this effect. The reason for Copepoda being the dominant group could be as a result of the weather condition, in wet season, the weather is cool and this promotes copepoda and cladocera population, also because copepod are fast and they shoot, this could hinder other groups from coming up. But in terms of species diversity, Rotifers has more species than any other group. Rotifera was the dominant group in dry season because of their ability to undergo vertical migration which minimizes competition through niche exploitation and food utilization (Ekpo *et al.*, 2015) and also due to harsh weather condition which support Rotifera population, then Cladocera (15.98%) and Copepoda (15.98%). In terms of species diversity, rotifers has more species than copepoda and Cladocera in both wet and dry season, although, rotifer species were higher in wet season than in dry season. Rainfall and flooding are among the features of wet season. Flooding washes down nutrients from watershed and farmlands into water bodies. The nutrients trigger off food production (phytoplankton). Also rich nutrient loading may support the high zooplankton abundance population (Manickam *et al.*, 2017; 2018). The lower abundance of zooplankton recorded in the dry season could also be due to predation by fish. Mahar (2003) reported physicochemical factors such as transparency; food availability, dissolved oxygen, and predation affect the population composition of zooplankton. All these factors were significantly higher in wet than in dry season which in turns affect the zooplankton population in both season.

CONCLUSION

At the end of the research work, it was found out that water quality, environmental activities and seasonal variation affect the growth and population of Zooplankton in Kisra Reservoir. Also D.O, Turbidity and Depth were significantly higher in wet season than in dry season while pH, Alkalinity were significantly higher in dry season than in wet season. There was no significant difference in water temperature, B.O.D and Conductivity across the seasons. Copepod dominant the population in wet season, followed by Cladocera then Rotifers in the time of this study while in Dry season, Rotifera dominant the population followed by Copepoda and Cladocera.

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BACTERIOLOGICAL ASSESSMENT AND PHYSICO-CHEMICAL PARAMETERS OF POND WATER IN JEGA LOCAL GOVERNMENT AREA, KEBBI STATE, NIGERIA

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ABSTRACT

Microorganisms contribute significantly to the aquatic ecosystem and they have been observed to be among the factors that can cause the emergence of infectious diseases in the practice of aquaculture. Thus, the need to assess the bacteria and some physico-chemical parameters of pond water in Jega Local Government Area. Water samples were collected from five (5) selected fish ponds between March to June, 2021. Bacterial load and physico-chemical tests were carried out using standard methods of analyses. The results on the bacteria load indicates mean range values of $6.30 \pm 0.02 \times 10^8$ cfu/ml - $12.60 \pm 0.05 \times 10^8$ cfu/ml. Species of bacteria identified includes; *Salmonella spp.*, *Escherichia sp.*, *Bacillus sp.*, and *Staphylococcus sp.* The range of values for some of the physico-chemical parameters are as follows; pH 6.70 ± 0.03 - 7.00 ± 0.02 , Chlorine ion 0.40 ± 0.02 - 1.2 ± 0.02 mg/L, DO 2.30 ± 0.30 - 3.50 ± 0.04 mg/L, BOD 12.29 ± 0.01 - 17.10 ± 0.04 mg/L. There was positive correlation between pH, DO and BOD when compared with Bacteria load, while significant negative correlation (-0.963) was observed between COD and bacteria load. Conclusively, the study infers that, certain pathogenic bacteria are associated with pond water. Furthermore, some physico-chemical parameters have significant impact on bacteria load.

Keywords: Bacteriological, Physico-Chemical Parameters, Pond Water and Jega

INTRODUCTION.

Fish are reared in different controlled environment which could be pond (Concrete or earthen), vats (wooden or fiber glass) and plastics (Njoku *et al.*, 2015). Among these culture system, concrete and earthen ponds are widely used (Ezenwa 2006). A pond is a body of water that is too small for wave action and too shallow for major temperature differences from top to bottom. It is referred to as a landlocked small mass of freshwater formed naturally or artificially and can be used for various purposes (Douglas and Isor, 2015). Pond water sources are useful for diversified purposes including aquaculture and other related uses at the domestic level (Eze and Ogbaran, 2010). Pond waters may be polluted due to discharge of effluents from various industries, domestic waste, land, feed and agricultural drainage; this causes a deleterious change in the water quality (Abu *et al.*, 2020). Physical characteristics of a fish pond directly impact pond water quality and indirectly the whole ecosystem and therefore, production management potential for the farmers. Pond water composition may be murky if it has a high number of suspended particles and organisms. Its bottom is usually sediments of sand, decaying matter and microorganisms. Pond ecosystems are often teeming with rich vegetation and a diverse organismal life. Ponds may however be contaminated by direct excretion (vomit, faeces) from fishes (Hoseinzadeh *et al.*, 2013). Bacteriological monitoring of ponds is based on natural knowledge of the sanitary condition of the water supply, which is based on the detection of coliform bacteria and the specific indicator of human faecal contamination (Idakwo and Abu, 2004). Microorganisms contribute a significant fraction of importance in the aquatic ecosystem and they have been observed to be among the factors that can cause the emergence of infectious diseases in the practice of aquaculture (Noga, 2000). The prevalence of infectious diseases has been observed to depend on the interaction between fish pathogens and the aquatic environment (Noga, 2000). More so, the placing of fish in ponds may expose them to new pathogens (Sasson, 1990). Great loss of fish has been attributed largely to bacterial infections. Attempts have been taken in order to assess the bacterial population in aquatic environment and their involvement in causing diseases in fishes. Considering the above reasons, the study was conducted to assess the bacteriological and physico-chemical parameters of fish pond water in Jega metropolis.

MATERIALS AND METHODS

Study Area

Jega and its satellite lies within latitudes $12^{\circ} 13^{\circ}$ and longitudes $4^{\circ} 5^{\circ}$ East. Jega local Government was created in 1976 and is traditionally hemmed on four axes by Argungu and Gwandu emirates to the North, Yauri and Zuru Emirates to the South and Southeast respectively. To the west it is bordered by Kalgo and Bunza Local Governments (Kebbi State), while at South-east it is hemmed by Aliero, South-west by Maiyama (Kebbi State), and twisted with Tambuwal and Kebbe Local Government Areas (Sokoto state) at South-east and South- west respectively.



Figure1: Map of kebbi state showing Jega (Source: <http://en.m.wikipedia.org/wiki/Jega>).

Sample collection

Water samples were collected from five (5) selected fish ponds with 1 liter of clean labeled polyethylene sample bottles, kept in an ice – packed container and transported to laboratory of the Department of Animal and Environmental Biology, Kebbi State University of Science and Technology Aliero, for bacteriological analysis and physico-chemical parameters.

Bacteriological Procedure

The bacterial load from the fish ponds were determined by performing eight-fold serial dilution of the sample in test tubes containing sterile distilled water. The total viable bacterial count was determined using the petri-dish plate. The plates were incubated at 35°C for 24hrs. The colonies were counted and expressed in colony forming unit per ml (cfu/ml) and values were estimated by means of duplicate determination. The isolated colonies were streaked on nutrient agar and bacteria isolates were subjected to various morphological and biochemical characterization tests to determine the identity of the bacteria isolates with reference to Bergey's Manual of Determinative Bacteriology (Buchanan and Gibbons 1974, Cheesbrough., 2006).

Physico-chemical parameters of fish pond water.

Physico-chemical parameters of the ponds were analyzed using standard methods. Water temperature was measured *in-situ* using glass bulb thermometer calibrated at (-10°C – 110°C) between 10 – 12GMT, Dissolved oxygen (DO) was analyzed using JPB – 608A portable analyzer, Chemical oxygen demand (COD), Total acidity, Total alkalinity, and Chlorine ions (Cl^{-}) content were determined by titrimetric method while dark reagent bottle was used for biological oxygen demand (BOD). The test took 5 days and it was performed using DO test kit. Samples of the pond water were taken with the DO level of each ponds using the DO test kit. Water samples were kept in a dark cupboard in complete darkness at 20°C for 5 days after which final readings of DO were taken. The final DO reading was subtracted from the initial reading to get final BOD in ppm. pH was analyzed using Jenway pH meter with model number 430.

Statistical analysis

The data collected were subjected to analysis of variance (ANOVA) and correlation analysis used to compare between bacterial load and physical chemical parameters.

Results and Discussion

As shown in Table 1, the highest value of bacterial load was observed in pond D with a mean value of 12.60 ± 0.05 , while the lowest value was observed in pond A with a mean value of 6.30 ± 0.02 . There was a significant difference ($P > 0.05$) comparing the highest value with the lowest value.

Table 1: Total Bacteria Count of Pond Water Samples

Samples	Total bacteria count ($\times 10^8$ cfu/ml)
Pond A	6.30 ± 0.02^a
Pond B	9.30 ± 0.03^b
Pond C	11.30 ± 0.04^d
Pond D	12.60 ± 0.05^e
Pond E	10.00 ± 0.02^c

Morphological characteristics and some biochemical characteristics including Gram staining reaction used gave probable identity of the isolate as seen on (Table 2). Bacteria species obtained found includes: *Escherichia spp*, *Salmonella spp*, *Bacillus spp*, *Staphylococcus spp*.

Table 2: Culture Characteristics of Isolated Bacteria

Samples	Catalase	Oxidase	Gram reaction	Organisms Found
Pond A	+	-	+	<i>Salmonella Spp</i>
Pond B	+	-	-	<i>Escherichia Spp</i>
Pond C	+	-	+	<i>Salmonella Spp</i>
Pond D	+	-	+	<i>Bacillus Spp</i>
Pond E	+	-	+	<i>Staphylococcus Spp</i>

As shown on Table 3, the highest pH value was recorded in pond D and E with a mean value of 7.00 ± 0.02 , while the lowest mean value 6.70 ± 0.03 was observed in pond A. Water temperature recorded same values 28.00 ± 0.03 in all ponds. In chemical oxygen demand (COD) the highest value was recorded in pond A with mean value of 7.38 ± 0.60 and the lowest value recorded in pond D with mean value of 6.80 ± 0.01 . In chlorine (CL-), the highest value was recorded in pond A and B with a mean value of 1.2 ± 0.02 , while the lowest value was recorded in pond E with a mean value of 0.40 ± 0.02 . Highest mean value of DO was recorded 3.50 ± 0.04 in pond C, while the lowest value 2.30 ± 0.03 was recorded in pond A. In biological oxygen demand (BOD) the highest value was recorded in pond C with a mean value of 17.10 ± 0.04 , while the lowest mean value 12.29 ± 0.01 recorded in pond A. Bacteria of public health importance like *E. coli*, *Salmonella sp*, *Bacillus sp* and *Staphylococcus sp* were also detected. There was significant difference ($P > 0.05$) in all the parameters except water temperature where it recorded same values in all ponds.

Table 3: Physico-chemical Parameters of Pond Water Samples

Water parameter	Pond A	Pond B	Pond C	Pond D	Pond E
pH	6.70 ± 0.03^a	6.80 ± 0.03^b	6.90 ± 0.003^c	7.00 ± 0.02^d	7.00 ± 0.02^d
Temp	28.00 ± 0.03^a	28.00 ± 0.03^a	28.00 ± 0.03^a	28.00 ± 0.03^a	28.00 ± 0.03^a
COD	7.38 ± 0.60^a	7.00 ± 0.20^a	6.92 ± 0.01^a	6.80 ± 0.01^a	7.10 ± 0.20^b
CL-	1.2 ± 0.02^d	1.2 ± 0.02^d	0.70 ± 0.04^b	0.90 ± 0.03^c	0.40 ± 0.02^a
DO	2.30 ± 0.03^a	2.60 ± 0.02^b	3.50 ± 0.04^c	3.20 ± 0.03^d	2.70 ± 0.02^c
BOD	12.29 ± 0.01^a	13.52 ± 0.05^b	17.10 ± 0.04^c	16.10 ± 0.90^d	13.80 ± 0.02^c

Keys: COD=Chemical Oxygen Demand, CL⁻=Chloride, DO=Dissolved Oxygen and

BOD=Biological Oxygen Demand

Correlation between physico-chemical parameters and bacteria load is presented in Table 4. A significant perfect negative correlation (-0.963) was observed between the COD and bacteria load. There was also positive correlation between the bacteria load and pH, DO and BOD, though not significant.

Table 4: Correlation between Physico-chemical Parameters and Bacteria Load

	Bacteria Load	pH	Temp	COD	CL	DO	BOD
Bactria Load	1	.855	-	-.963**	-.169	.865	.875
pH	.855	1	-	-.716	-.384	.620	.617
Temp	-	-	-	-	-	-	-
COD	-.963**	-.716	-	1	-.079	-.821	-.835
CL	-.169	-.384	-	-.079	1	-.320	-.312
DO	.865	.620	-	-.821	-.320	1	.999**
BOD	.875	.617	-	-.835	-.312	.999**	1

** . Correlation is significant at the 0.01 level (2-tailed).

The result of the study revealed that Gram negative bacteria were the dominant genera among the pond organisms. This phenomenon has previously been reported by studies exploring the diversity of microflora in various types of ponds. The bacteria identification revealed the presence of four (4) isolates; *Escherichia coli*, *Salmonella typhi*, *Staphylococcus aureus* and *Bacillus subtilis*. This may be as a result of contamination from fish feeds and pond fertilization. The coliforms isolated were an indication of the contamination of the pond water with faecal materials which may be as a result of source of water used for fish farming, composition of fish feeds, poor sanitary level of the farms and fertilization of the ponds with organic manure which is inoculated directly into the fish ponds. The diverse groups of bacteria isolated from these ponds are in line with the report of Daboor (2008) who worked on pond water suggesting that allochthonous bacteria from feed added to the ponds are the principal source of bacteria and Odera *et al.*, (2020) who reported similar organisms on the physico-chemical, bacteriological and parasitological examination of selected fish pond water samples in Awka and Its Environment. The presence of pathogenic microorganisms especially *Salmonella typhi*, *Escherichia coli* can lead to the transmission of water borne diseases such as, Diarrhea. *Salmonella* sp specifically was the predominant group of bacteria isolated in this study (Pond A and C).

The analysis of the total bacterial count in the water samples revealed the presence of heterotrophic bacteria in all the fish pond waters. The presence of counts exceeding the W.H.O limits indicates that the water samples contain high concentration of bacteria that could make the water unsafe for fish. The result of this study agrees with the findings of Njoku *et al.*, (2015). who recorded 6.5×10^5 cfu/ml to 7.4×10^5 cfu/ml for concrete fish pond water samples in Niger Delta, Nigeria and stated that the fish pond water samples had bacterial count above the admissible limit of 100 cfu/ml for optimum fish productivity and also in agreement with the findings reported by Adedayo, and Okoh (2014) in their study bacteriological study of pond water for aquaculture purposes which values ranges from 8×10^4 cfu/ml to 24×10^4 cfu/ml in Akungba. Coliforms isolated were indication of the contamination of the pond water with faecal material and pose a threat to the health of the fishes and the consumers and are the potential problem in the pond effluents management. The faecal materials may be excreted into the ponds by the fish or through runoff (Kay *et al.*, 2008), water used in the fish farming, composition of fish feed and poor sanitation. The presence of pathogenic microorganisms can lead to the transmission of water borne diseases. The presence of these organism shows lack of qualitative pond management service which could become harmful to both fish and humans in the food web system. From the investigation, there is a need to monitor water quality from time to time to find out the source of contamination and to pass water treatment to prevent epidemic outbreak that can lead to mortality.

Temperature is a factor of great importance for aquatic ecosystem, as it affects the organisms as well the chemical and physical characteristics of water. The temperature obtained from the study was within the limit that will support fish productivity. The temperature of the pond normally follows that of its surrounding depending on the size of the pond. The values of water temperatures observed in this study were within the optimum range for culture of aquatic organisms as reported by Solomon Wisdom *et al.*, (2013) who stated that the best water temperature ranges from 25 - 31°C. The result from the study is also in agreement with that of (Ntegwu and Edema 2008, Njoku *et al.*, 2015) who reported the optimum condition for increased fish productivity to range from 20°C to 30°C.

pH measurement will help to determine if the water is a proper place to put a fish. Although most fish can tolerate a pH as low as 5.0. The pH recorded in the pond for this study were within the range required for aquaculture (6.5 – 9.5), thus suitable for fish production. The pH values obtained from the various pond water samples were within the optimum for the survival of the fish and similar to study of (Ehiagbonare and Ogunrinde 2010) who study the physico-chemical analysis of fish pond water in Okada, Edo State to range between 6 - 9. The biological oxygen demand (BOD) and chemical oxygen demand (COD) are also important parameters in water habitat and also in fish pond. High values of BOD imply high demand for oxygen to support life processes. The result of the study is similar with the result of Odewumi and Zakeri (2010) who recorded a higher value of BOD and COD in the study of catfish pond in Jos suggesting that the fish pond was polluted. The BOD fluctuation observed may be attributed to pollution from fish feed. Dissolved Oxygen (DO) is defined as the measure of the amount of gaseous oxygen dissolved in an aqueous solution (Odera *et al.*, 2020). It has been reported that natural water is saturated with dissolved oxygen in equilibrium with air. The concentration at this saturation is known to decrease as the temperature of water increases. The DO obtained in this study was below 5mg/l required for fish production. The low DO obtain may be attributed to increase in microbial and organic load and metabolic activity may also account for low DO concentration. Low concentration of dissolved oxygen in water causes suffocation in fish while its super saturation may result into the gas bubble disease leading to the mass mortality of fish in both cases. Oxygen depletion in water leads to poor feeding of fish, starvation, poor distribution of fishes, reduced growth and more fish mortality, either directly or indirectly. The DO values obtained from the fish pond water samples are not within the W.H.O permeable limit of >5 mg/l. This may be as a result of higher microbial load, high stocking density and phytoplankton in the studied ponds. The study also shows that, Chemical oxygen demand could be a factor in determining bacteria load in aquatic environment.

CONCLUSION

The study provided information about the water quality status of some selected fish pond in Jega Area and its suitability for aquaculture. The water quality varies considerably between sources at different locations. The field observations on the water quality revealed that the study area have high potential for aquaculture development based on the values obtained which were in conformity with recommended values for fish pond water.

Sanitary conditions under which fish are reared in ponds should be improved, by following standard or good practices; such as use of good quality water, use of feeds with high microbial quality, regular draining of pond water after specific period of time, closure of ponds to the public among other things. Continuous monitoring of these physico-chemical parameters of pond would give farmers firsthand information on strategies to employ in preventing and reducing fish disease and mortality. The study also revealed that fish ponds should be properly managed so that consumers of fish will not be exposed to infectious diseases and chemicals that may affect the body systems.

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DISTRIBUTION AND SPECIES DIVERSITY INDEX OF MACRO-INVERTEBRATES OF KIRI RESERVOIR, ADAMAWA STATE, NIGERIA

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Abstract:

A study on Evaluation of Benthic Macro-invertebrates of Kiri reservoir was conducted over a period of eighteen months (September, 2017- February, 2019) using standard methods. The individuals and monthly diversity index of the Macro-invertebrates revealed low diversity and species richness at the study sites with Shannon Weiner index of 2.044 and 1.169-2.588 respectively. A total of four hundred and twenty-six (426) macro-invertebrate were observed during the period of this study. The Macro-invertebrates were represented by 9 family, with one species each (truncatus, hirudo, Lestes, *Dorylamus sp.*, *Lantus sp.*, Culiciomyia, Chironomide, *M. latex*, Caenis). Kiri Reservoir is dominated by group of macro-invertebrates such as Lantus sp. (20.89%), Lestes (20.66%) and Caenis sp. (15.73%). The diversity index for both individual species and monthly index ranged from 1.169-2.588. Suggesting that, Kiri Reservoir is moderately polluted.

Keywords: Benthic, Kiri, Lantus, Macro-invertebrates, Reservoir

INTRODUCTION

Benthic macro-invertebrates are organisms in the aquatic environment without backbone that live on or inside the deposit at the bottom of a water body. These organisms play an important role in aquatic community, which includes mineralization, mixing of sediments, flux of oxygen into sediments, cycling of organic matter and also in assessing the quality of inland water. Benthic macro-invertebrate species are differentially sensitive to biotic and abiotic factors in their environment. The distribution of these macro-invertebrate fauna is determined by several factors such as the physical nature of the substratum, depth, and nutritive content, degree of stability and oxygen content of the water body (Sharma *et al.*, 2013). Macro-invertebrates have been used as indicators of environmental conditions especially in evaluating the impacts of specific pollutants in the aquatic environment because of their limited mobility, long life period, their sensitivity to changes in their environment and tolerance of some to contamination (Flores and Zafaralla, 2012 and Sharma *et al.*, 2013). Their community characteristics such as diversity, richness and abundance, are often used as indicators of the degree of pollution of bodies of water, to supplement and deepen the meaning of physicochemical information (Edward and Ugwumba, 2011). Macro-invertebrates being a bio-monitor species in determining eutrophication, pollution and water quality in freshwater bodies are vastly studied in different parts of the world (Mishra and Nautiyal, 2013).

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.

Benthic macro-invertebrates were collected from three sampling points during the period of the study. The organisms were collected using D-framed net. The net was positioned facing the upstream. A designated "kicker" disturbed the area upstream at a distance about one meter. The net was lifted out of the water with a forward scooping motion to prevent any of the organisms it contained to wash away; after which the contents of the net was poured into a bucket with water. Non-macro-invertebrates caught was immediately

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returned to the stream. The collected macro-invertebrates were preserved in 70 % ethanol on the site and identified in the laboratory using the reference guide of Bouchard (2004).

RESULTS AND DISCUSSION

The mean monthly distribution and abundance, of Macro-invertebrate is presented on table 1. Nine (9) species of Macro-invertebrate were identified during the period of this study. *Lantus sp.* recorded the highest 87(21.91%) distribution and abundance of the Macro-invertebrate at the three study sites, while *M. latex* was observed to be the lowest distributed 16 (4.03%) species of the Macro-invertebrate. Mean monthly and individual diversity index recorded 2.044 and 1.169 – 2.588 (Table 2 and 3). There was significance differences across months ($p>0.05$).

The individuals and monthly diversity index of the Macro-invertebrates revealed low diversity and species richness at the study sites with Shannon Weiner index of 2.044 and 1.169-2.588 respectively. McDonald, (2003) stated that the value of the index ranging from 1.5-3.4 have low diversity and species richness, while value above 3.5 has high diversity and species richness. Wilm, (2007) suggested a relationship between species diversity and pollution status of aquatic system and classified as >3 = clean water, $1-3$ = moderately polluted, <1 = heavily polluted. Based this classification, Kiri Reservoir is moderately polluted. Macro-invertebrates have been used as indicators of environmental conditions especially in evaluating the impacts of specific pollutants in the aquatic environment because of their limited mobility, long life period, their sensitivity to changes in their environment and tolerance of some to contamination. A total of four hundred and twenty six (426) macro-invertebrate belonging to nine species were observed during the period of this study. This varied with four hundred and thirty three (433) belong to three phyla Arthropod, Annelid and Mollusc reported for Lake Geriyo (Kefas, 2016). Characteristically, Kiri Reservoir is dominated by group of macro-invertebrate such as *Lantus sp.* (20.89%), *Lestes* (20.66%) and *Caenis sp.* (15.73%). Dragon flies, Damsel flies and lestes were reported to be higher at Lake Geriyo, Upper Benue River and Nzovwe stream (Kefas, 2016; Fredrick and Hudson, 2016).The presence of snails suggests potential pollution in the area most probably because the area is vulnerable to various impacts such as dumping of domestic wastes, and vehicles passing by as the dam was constructed across the reservoir, agricultural activities such as animals wallowing and wading in the reservoir, and other anthropogenic activities. These activities could have altered the physical and chemical quality of water necessary for the occurrence of macro-invertebrates. The low number of *M. latex* (4.03%) recorded might be due to low free carbon dioxide, higher ammonia and higher concentration of heavy metals such as manganese resulting from anthropogenic activities and lithological process (Mamman, 2021). Low species richness observed might also indicate devastating impact of impoundment on the benthic macro-invertebrate and pollution stress in the area due to increased human activities. Similar observations were made for some water bodies (Arimoro *et al.*, 2007; Andem *et al.*, 2012; Edward and Ugwumba, 2011; Latha and Thanga, 2010).It was found that agricultural activities, lithological process, indiscriminate fishing activities, washing and bathing could alter physicochemical parameters of the reservoir and hence changing the abundance of macro-invertebrates as well as the quality of water.

Table 1: Monthly Distribution of Macro-invertebrate of Kiri Reservoir

	Species	Sept., 2017	Oct.	Nov	Dec.	Jan., 2018	Feb.	Mar	Apr	May	Jun.	Jul.	Aug	Sept	Oct.	Nov	Dec.	Jan., 2019	Feb.	Total	%
Planorbidae	Truncates	2	3	-	1	-	2	-	3	5	1	4	2	-	2	3	1	-	1	30	7.04
Hirudidae	Hirudo	3	2	-	-	1	2	-	-	-	2	1	4	3	-	-	1	2	3	24	5.63
Zygoptera	Lestes	6	8	3	2	1	5	3	2	5	7	5	8	9	7	8	3	5	1	88	20.66
Dorylaimidae	Dorylamus sp	1	2	1	-	-	-	-	2	5	1	-	3	-	1	2	1	3	-	22	5.16

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Gomphidae	Lantus sp.	8	9	5	6	6	8	3	2	6	7	4	2	5	2	3	5	3	5	89	20.89
Cullcidae	Culiciomyia	2	1	3	4	2	3	6	4	2	1	3	5	5	2	3	1	3	2	52	12.21
Chironomidae	Chironomide	3	1	1	1	2	3	4	1	1	1	4	3	3	2	1	3	2	1	37	8.69
Noctimidae	M. latex	1	2	1	-	-	-	-	2	1	3	2	1	1	1	-	-	2	-	17	3.99
Caenidae	Caenis sp	1	2	4	5	3	6	7	3	3	2	4	1	4	2	6	5	4	5	67	15.73
Total		27	30	18	19	15	29	23	19	28	25	27	29	30	19	26	20	24	18	426	100

Table 2: Individual Species Diversity Index of Macro-invertebrates

Family	NUMBER OF INDIVIDUALS (n)	n/N	Pi	Pi ²	LnPi	PilnPi
Planorbidae	30	30/426	0.070	0.005	-2.656	-0.186
Hirudidae	24	24/426	0.056	0.003	-2.882	-0.162
Zygoptera	88	88/426	0.207	0.043	-1.575	-0.326
Dorylaimidae	22	22/426	0.052	0.003	-2.957	-0.154
Gomphidae	89	89/426	0.209	0.044	-1.565	-0.327
Cullcidae	52	52/426	0.122	0.015	-2.104	-0.257
Chironomidae	37	37/426	0.089	0.008	-2.442	-0.212
Noctimidae	17	17/426	0.040	0.002	-3.219	-0.129
Caenidae	67	67/426	0.157	0.025	-1.852	-0.291
Total	426					-2.044

S (Number of species) = 9; N (Total number of individuals) = 426; $\sum$ (Sum) of $\pi^2 (n/N)^2 = 0.140$

$\sum$ (Sum) of $\text{PilnPi} = -2.044$

$H = -(-0.186 + -0.162 + -0.326 + -0.154 + -0.327 + -0.257 + -0.212 + -0.129 + -0.291) = 2.044$

$D = 1 / (0.005 + 0.003 + 0.043 + 0.003 + 0.044 + 0.015 + 0.008 + 0.002 + 0.025) = 1/0.148 = 6.757$

Table 3: Monthly Species Diversity Index of Macro-invertebrates

Months	Number of individuals (n)	Percentage (%)	Diversity index (D)
Sept 2017	27	6.34	2.542
Oct 2017	30	7.04	1.894
Nov 2017	18	4.23	1.976
Dec 2017	19	4.46	1.592
Jan 2018	15	3.52	1.586
Feb 2018	29	6.81	1.817
March 2018	23	5.40	1.547
April 2018	19	4.46	2.016
May 2018	28	6.57	1.187
June 2018	25	5.87	2.588
July 2018	27	6.34	2.001
Aug 2018	29	6.81	1.997
Sept 2018	30	7.04	1.800
Oct 2018	19	4.46	1.169
Nov 2018	26	6.11	1.769
Dec 2018	20	4.69	1.862
Jan 2019	24	5.63	1.831
Feb 2019	18	4.23	1.74

Conclusion

In conclusion, Kiri Reservoir is dominated by group of macro-invertebrate such *Lantus sp.* (20.89%), *Lestes* (20.66%) and *Caenis sp.* (15.73%) and low number of *Aplecta spp* (4.03%) was recorded. Low species richness observed might also indicate devastating impact of impoundment on the benthic macro-invertebrate and pollution stress in the area due to increased human activities.

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LIMNOLOGICAL PROPERTIES AND WATER QUALITY OF SOMBREIRO RIVER, PORT HARCOURT, NIGERIA

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ABSTRACT

The limnological characteristics and water quality of Sombreiro river was studied between March to May, 2021 with the water samples collected from the 3 stations analyzed in the laboratory following standard method of APHA. The results of the water parameters studied showed that the mean values were as follows: pH, 6.66 ± 0.15 , Temperature, $30.01 \pm 0.42^{\circ}\text{C}$, Electrical conductivity (EC), $120.1 \pm 39.4 \mu\text{s/cm}$, Dissolved Oxygen (DO), $5.40 \pm 0.18 \text{mg/l}$, Biological Oxygen Demand (BOD), $4.17 \pm 0.29 \text{mg/l}$ while the values for the nutrients, sulphate (SO_4), Phosphate (PO_4) and nitrate (NO_3) were respectively, $14.10 \pm 0.94 \text{mg/l}$, $0.46 \pm 0.07 \text{mg/l}$ and $1.37 \pm 0.11 \text{mg/l}$. From the results only pH, DO and nitrate did not differ significantly spatially at probability level of $P \leq 0.05$. The water variables were all within the permissible limits recommended by WHO, SON and EPA. Sombreiro river is therefore not stressed and therefore suitable for survival and growth of aquatic biota. Therefore, adequate measures should be taken to ensure that anthropogenic activities in the area are monitored to avoid discharge of harmful wastes into the area capable of causing contamination or pollution of the area.

Keywords: Limnological Properties, Water Quality, Sombreiro River, Port Harcourt.

INTRODUCTION

Water which makes up to 60-95% of the total weight of any functioning living cell (Tutor *et al.*, 2015), is one of the most important substances upon which human life and indeed all life on earth depends (Al-Ridah *et al.*, 2020). Physicochemical variables help 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 number of pollutants in the form of nutrients and solids. The physical and chemical characteristics of water are important determinants of water quality and consequently its suitability for the distribution and production of fish and other aquatic animals (Swingle and Moss, 1969). Oyewo and Don Pedro (2003) reported that variability of water quality influences the toxicity levels of heavy metals on estuarine organisms as it affects the physical and chemical composition of the ecosystem.

In Africa a large proportion of both rural and urban population live in the vicinity of inland or coastal waters showing that traditional human populations have tended to settle close to natural waters because they offer man's greatest hopes for food and material supplies. For instance, coastal waters provide fertile environment serving as important nursery grounds for many marine and freshwater organisms. The wetlands shelter and provide transit facilities for migrant birds, and the mangroves protect the coastline against erosion while inland waters serve as a ready source of portable water. They also act, in common with coastal waters as a place for transportation and recreation and a source of energy. Furthermore, inland and coastal waters are important ecosystem complexes for fisheries and aquaculture development (FAO, 1991). 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 Orogodo 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 variations in zooplankton.

The Sombriero River system is one of the most important river systems in the Niger Delta Basin, providing nursery and breeding grounds for a large variety of fish species and source of livelihoods for the inhabitants hence this research. Although this environment is threatened by pollution resulting from industrial activities,

human anthropogenic activities and others as they discharge their effluents directly into the river irrespective of the major roles it plays to the community especially for their protein source and livelihood and for transportation. This study therefore intended to assess the variability and status of some physicochemical variables of this river.

MATERIALS AND METHODS

Study area and Sampling Locations

The study was carried out at the middle reaches of the Sombreiro River where three areas in the river were located as sample sites. The locations sampled were Abonnema (Latitude 4°42'55.56"N and Longitude 6°46'24.29"E), Degema (Latitude 4°45'27.63"N and Longitude 6°45'31.18"E) and Krakrama (Latitude 4°44'56.33"N and Longitude 6°46'42.57"E). The Sombreiro River is located east of the Orashi River and originates from swamps in the Oguta-Ebocha zone. It has its source from the Niger River, runs downwards into the Southern tip of the Niger Delta basin and empties into the Atlantic Ocean.

Sampling Collection and Analysis

The water samples for limnological parameters were collected once a month for three (3) months between March and May 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 others 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 23 at 1% and 5% confidence levels ($P \leq 0.05$). Pearson correlation test was also carried out to demonstrate correlation between the limnological parameters.

Results and Discussion

pH ranged between 6.40 and 6.90 with the overall mean value of 6.66 ± 0.15 without significant spatial variation (Table 1 & 2). This observed pH range is acidic and within that considered permissible for aquatic life. The pH range obtained in this study is comparable with the 6.20 and 7.90 reported by Otene and Iorchor(2013) Amadi-Ama, Bonny Estuary. Temperature ranged between 29.50°C and 30.50°C with the mean value of $30.01 \pm 0.42^\circ\text{C}$ (Table 1). This result is also in line with the finding of Davies and Otene (2009) who reported temperature range of 29.50 ± 0.02 and $30.25 \pm 0.03^\circ\text{C}$ in Minichinda stream. The slight spatial and temporal variations (figure 1-4) observed in this study could be attributed to change in climate conditions, degree of exposure to sunlight and surrounding vegetations. Electrical conductivity ranged from 140.50 -1500 $\mu\text{S}/\text{cm}$ with mean value of 120.1 ± 39.4 (Table 1-2). The mean conductivity value recorded in this study is in line with Kosa (2007) and Deekae (2009) in Luubara Creek. The significant difference between stations observed in this study may be attributed to difference in environmental factors owing to nutrient regenerating from bottom sediment, decomposition, heavy run-off and mineralization of microbes. Dissolved oxygen with the mean value of $5.40 \pm 0.18 \text{ mg/l}$ 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 sulphate showed significant relationship spatially at probability level of $P \leq 0.05$. Spatial variation of P_04 and SO_4 with the highest value in station 2 (Table 2) could be due to increased human faeces and high level of utilization of detergent by the teaming population in the area.

Table 1: Overall Mean Values and Ranges of Physico-chemical parameters in the Study Area

Parameters	Mean	Minimum- Maximum		WHO	SON	EPA
pH	6.66 ± 0.15	6.40	6.90	6.5-7.5	6.5-8.5	6.5-8.5
Temp	30.01 ± 0.42	29.50	30.5	25	Ambient	NS
EC	120.1 ± 39.4	15.5	140.5	1500	1000	4.7-5.8

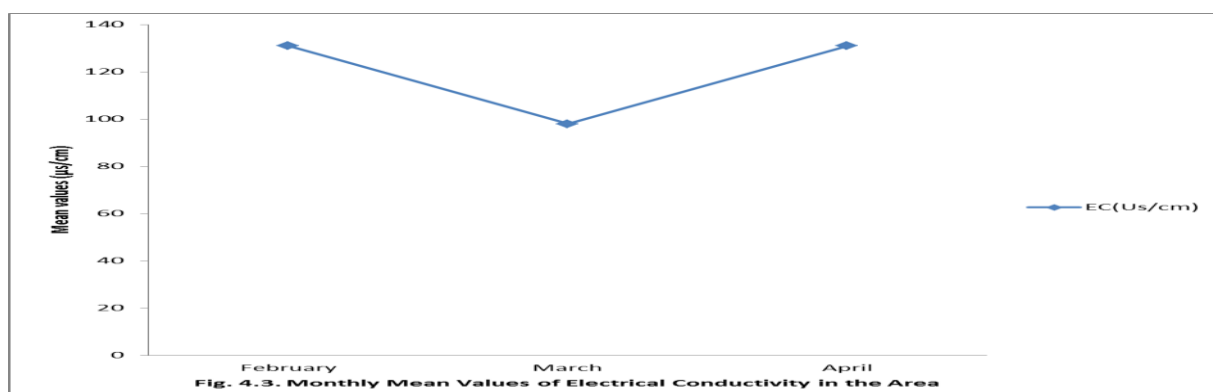
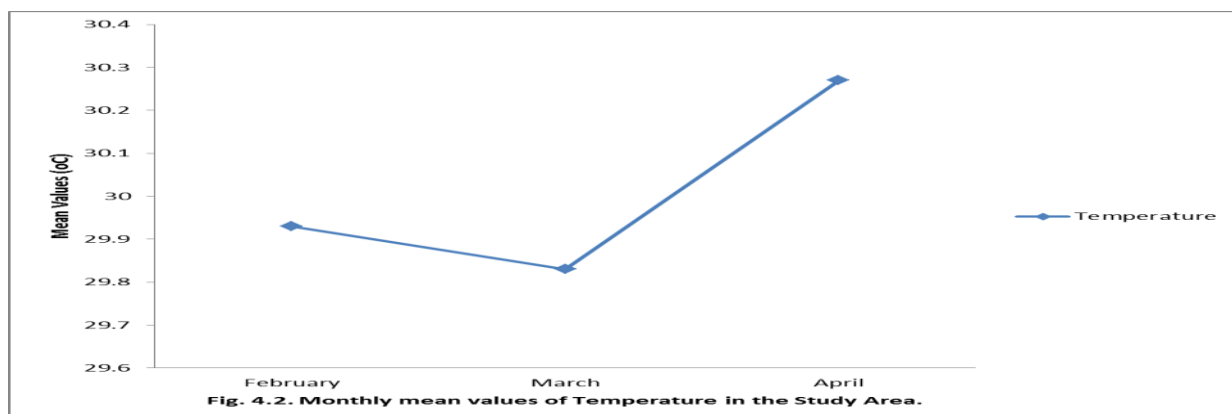
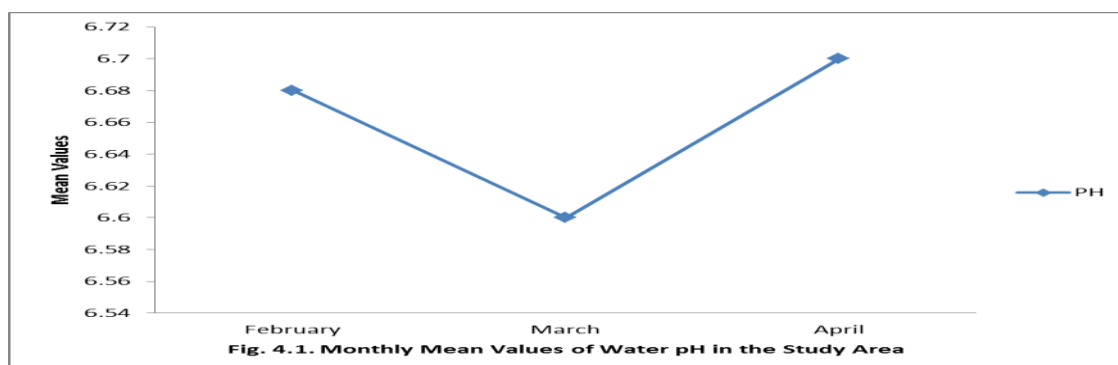
DO	5.40±0.18	5.10	5.60	15	NS	NS
BOD	4.17±0.29	3.70	4.60	10	NS	NS
SO ₄	14.10±0.94	12.5	15.7	200	100	250
PO ₄	0.46±0.07	0.39	0.60	0.5	0.01-0.03	NS
NO ₃	1.37±0.11	1.26	1.60	10	10	10

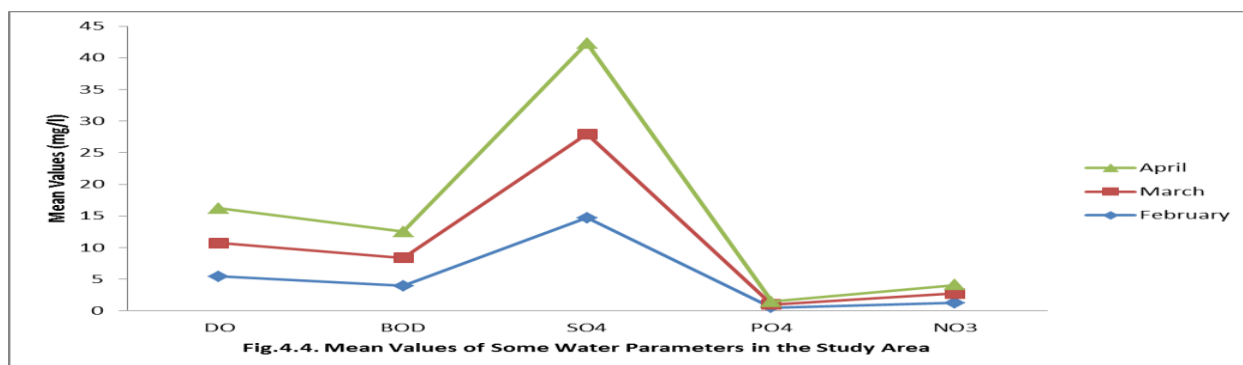
WHO: World Health Organisation (2004). **SON:** Standards Organization of Nigeria (2007). **EPA:** Environmental Protection Agency (2002). **NS: Not Stated**

Table 4.2: Spatial Mean Value of Physico-chemical Parameters in the Study Area

Stations	pH	Temp(°C)	EC($\mu\text{S}/\text{cm}$)	DO(mg/l)	BOD(mg/l)	SO ₄ (mg/l)	PO ₄ (mg/l)	NO ₃ (mg/l)
Station1	6.57±0.06 ^a	29.83±0.58 ^a	133.1±6.54 ^a	5.37±0.21 ^a	4.07±0.47 ^a	13.38±0.76 ^b	0.42±0.05 ^b	1.33±0.06 ^a
Station2	6.65±0.22 ^a	30.37±0.12 ^a	135.3±2.25 ^a	5.36±0.24 ^a	4.30±0.24 ^a	14.80±0.90 ^a	0.53±0.58 ^a	1.42±0.17 ^a
Station3	6.76±0.12 ^a	29.83±0.29 ^a	91.83±66.11 ^b	5.493±0.095 ^a	4.13±0.06 ^a	14.13±0.76 ^a	0.43±0.06 ^b	1.35±0.09 ^a

Means with similar superscript across the column is not significant at P<0.05





CONCLUSION AND RECOMMENDATION

The results of this study showed that Sombreiro river is stressed despite the numerous anthropogenic activities in the area and therefore considered suitable for production of fishes and other aquatic biota. Based on the ongoing anthropogenic activities adequate monitoring should be carried out to restrict uncontrolled and indiscriminate dumping of organic matter or wastes into the area which will in future pose environmental hazards.

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USE OF PHYSICOCHEMICAL CHARACTERISTICS FOR PROFILING WATER QUALITY OF THE LOWER ORASHI RIVER, IN NIGER DELTA, NIGERIA

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ABSTRACT

The study to profile Orashi river water quality was conducted to assess the magnitude of deterioration on the water quality of this aquatic ecosystem. To achieve this, eight essential physicochemical parameters such as: Dissolved Oxygen, water pH, Electrical Conductivity, Temperature, Turbidity and Salinity, were examined on-site all through the bi-weekly sampling for 3 months (October- December, 2021), with the aid of handheld instrument like thermometer for Temperature while Biochemical Oxygen Demand was analysed in the laboratory using standard analytical method. The result of the study revealed mean DO showed spatial and monthly variation ($p < 0.05$), EC was found to exhibit monthly variation and Total Dissolved Solids followed same trend as EC. Summary of the study proved all the parameters were within the permissible limit for both national and international regulatory agencies except for turbidity. Therefore, this river water is good for domestic and agricultural use, although requires close monitoring to avoid activities that will contaminate the water quality.

Keywords: Physico-chemical characteristics, water quality, aquatic ecosystem, Orashi river

INTRODUCTION

Rivers are the major sources of water in many countries, unfortunately, due to adverse anthropogenic pressure, the aquatic environment like rivers are faced with direct and indirect discharges of both household and industrial wastes with the ability to debase the river water quality (Arafat *et al.*, 2021). Over the years, the issue of aquatic pollution has become endemic in most rivers within the Niger delta axis of Nigeria, and one river of such report is the Orashi river (Edori and Aniekan, 2021).

The Orashi River is a non-tidal freshwater aquatic ecosystem of significance importance in the lower Niger basin, which flows through major communities of Ogba, Egbema and Ndoni in Rivers State, and few other communities in Imo State (Okwodu *et al.*, 2022). This river serves array of purposes such as drinking, irrigation for agrarian communities, fishing point and other domestic uses. But the advent of industries and oil exploration within the Ogba/Egbema/Ndoni areas of Niger Delta, have brought about impairment of the river water quality, particularly, the physicochemical parameters known as major determinants for water suitability. Therefore, the study on the use of physicochemical characteristics as profiling tool for water quality of the lower Orashi river, is aimed to assess and provide basic information on the quality water of this aquatic ecosystem.

MATERIALS AND METHOD

Study Area

The study was conducted on the Orashi river, a non-tidal freshwater ecosystem of significant importance in lower Niger basin, which originates from Oguta in Imo State and flows through communities in Enginni, Ogba, Ndoni and Egbema, then empties into Sombreiro river around Abonnema in Kalabari through central Abua, all in Rivers State, Nigeria (figure 1). Most communities around this watercourse are known for their beehive of activities ranging from oil exploration, sand dredging, fishing and crop farming. Amongst these communities are: Okarki (STN₁), Okparaki (STN₂), Ikodi (STN₃) and Kunusha (STN₄). This area lies

between latitude 4° 59' N and longitude 6° 28' E, and the average monthly temperature range between 23 to 30.50° C.

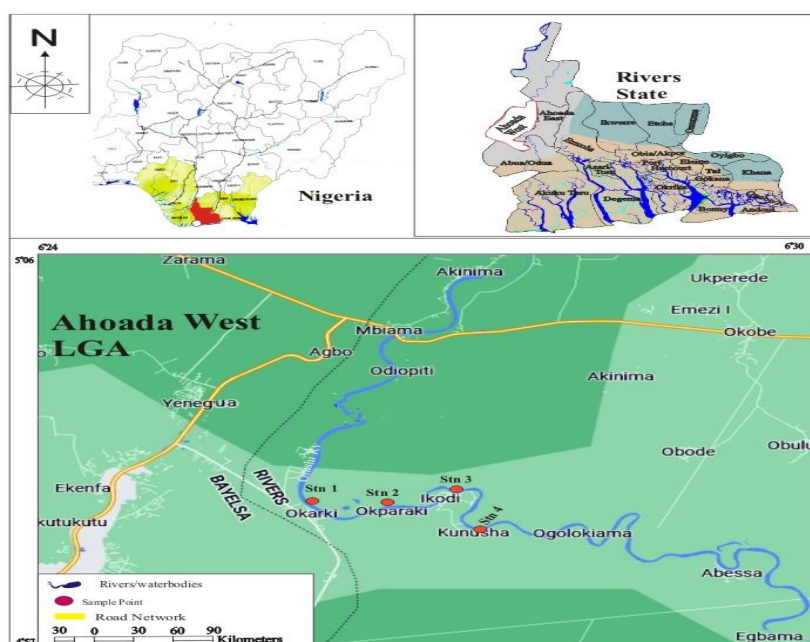


Fig.1: Map of study area, showing the sampling locations

Samples of Orashi river water were collected at four different points as shown in (fig 1), and each location was 500 metres away from the other. The sample collection was done bi-weekly for three months (October-December 2021), and each of the water samples collected was filtered to remove suspended solid particles with the aid of Whatman 41 filter paper. The vial containers used to collect the samples were kept airtight, preserved and later analysed with the use of instrument.

Method of Analysis

Eight (8) essential physicochemical parameters were analysed on-site to check the water quality, and the parameters include: Dissolved Oxygen, Electrical Conductivity, Total Dissolved Solids, water pH, Temperature, Turbidity, Salinity and biochemical oxygen demand. With the use of a handheld digital multi-meter checker (Extech model Do 700), Turbidity, Temperature, Total Dissolved Solids, pH, Electrical Conductivity and Salinity were determined. As for Dissolved Oxygen, it was measured with the aid of Milwaukee DO metre (MW 600) while the 250 ml amber bottles used to collect water samples across the stations, were transported in ice-chest to the laboratory and analysed for BOD using standard analytical procedure.

Statistical Analysis

Data obtained from this study were subjected to analysis using a one-way analysis of variance (ANOVA) at a confidence limit of 95% to determine spatial and monthly variations.

Results and Discussion

Table1: Spatial variation in physiochemical parameters of Orashi River

Parameter	ST _{N1}	ST _{N2}	ST _{N3}	ST _{N4}	P-value
DO (mg/l)	4.93 ± 0.15 ^a	5.17 ± 0.29 ^{ab}	5.17 ± 0.15 ^{ab}	5.47 ± 0.35 ^b	0.158
EC (µs/cm)	25.17 ± 2.70 ^a	26.50 ± 0.54 ^a	22.90 ± 6.67 ^a	23.77 ± 5.31 ^a	0.767

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TDS (mg/l)	14.94 ± 3.84 ^a	15.88 ± 1.30 ^a	13.32 ± 5.35 ^a	14.50 ± 4.72 ^a	0.896
PH	8.21 ± 0.26 ^a	8.30 ± 0.14 ^a	8.35 ± 0.40 ^a	8.68 ± 0.60 ^a	0.043
Temperature(°C)	27.60 ± 0.10 ^a	27.57 ± 0.06 ^a	28.30 ± 0.17 ^b	28.63 ± 0.06 ^c	0.000
Turbidity(NTU)	26.74±14.40 ^{ab}	14.33 ± 3.25 ^{ab}	8.39 ± 2.09 ^a	30.95 ±14.25 ^b	0.088
Salinity (mg/l)	0.02 ± 0.00 ^b	0.01 ± 0.01 ^a	0.01 ± 0.00 ^a	0.17 ± 0.58 ^a	0.009
BOD (mg/l)	0.57 ± 0.45 ^a	0.73 ± 0.60 ^a	0.73 ± 0.25	0.83 ± 0.55	0.915

Table 2: Monthly Variation in Physicochemical Parameters

Parameter	Oct	Nov	Dec	P- value
DO(mg/l)	5.40 ± 0.32 ^b	5.18 ± 0.28 ^{ab}	5.00 ± 0.13 ^a	0.111
EC(µs/cm)	20.27 ± 4.82 ^a	26.30 ± 0.04 ^b	24.59 ± 4.08 ^b	0.013
TDS(mg/l)	10.13 ± 2.81 ^a	16.98 ± 0.27 ^b	16.89 ± 0.48 ^b	0.000
pH(mg/l)	8.94 ± 0.62 ^a	8.79 ± 0.52 ^a	8.92 ± 0.54 ^a	0.922
Temp(°C)	27.99 ± 0.52 ^a	28.10 ± 0.59 ^a	28.00 ± 0.49 ^a	0.941
Turbidity(NTU)	20.65 ± 12.10 ^a	19.92 ± 11.33 ^a	19.74 ± 18.44 ^a	0.996
Salinity(mg/l)	0.02 ± 0.01 ^a	0.13 ± 0.01 ^a	0.04 ± 0.00 ^a	0.748
BOD(mg/l)	1.10 ± 0.14 ^b	0.50 ± 0.50 ^a	0.60 ± 0.24 ^a	0.054

The results of the monthly and spatial variation of physiochemical properties such as dissolved oxygen, electrical conductivity, total dissolved solids, water pH, temperature, turbidity, biochemical oxygen demand and salinity were recorded at ST_{N1}, ST_{N2}, ST_{N3} and ST_{N4} as shown in (fig1) for 3 months (Oct-Dec) and the results are presented in table 1 and 2.

The mean of dissolved oxygen in water samples collected at station 1 (ST_{N1}), showed statistical difference ($p < 0.05$) with the DO mean in station ST_{N4}, whereas ST_{N1}, ST_{N2} and ST_{N3} showed no statistical variation from each other. In terms of monthly variation, the DO value showed higher mean in October compared to the months of November and December with lower DO values. Conversely, the higher mean DO in October being rainy season in most tropical and this may have caused lower temperature that permits solubility of dissolved oxygen (Okey-Wokeh *et al.*, 2020). According to the DO value observed in this study, it is within the range of values provided for stable aquatic environment for fish and other organisms to thrive (World Health Organization 2017).

The summary of electrical conductivity as shown in Table 1 and 2, revealed that the values of EC observed across the stations showed no statistical variation ($p > 0.05$) with each other, except in terms of monthly variation with the value recorded in October showing significantly lower mean compared to November and December with no statistical difference. The lower mean EC observed in Oct could be due to inflow of water into the river and this finding is similar with that of Arafat *et al.*; (2021). The EC mean recorded in this study is within the national and international standard for domestic water use. Total dissolve solids followed similar trend with EC in both spatial and monthly variation. Similar results observed in this study in terms of TDS, were reported previously by other researchers in Orashi river (Edori and Edori 2021, Okwodu *et al.*, 2022). The mean TDS observed in this study is within 500 mg/l stipulated for drinking water (World Health Organization; 2017).

The mean water pH in this study as shown in Table 1 and 2 revealed there was no spatial and monthly variation. The result specifies the river was moderately alkaline, which is contrary to the slightly acidic result previously reported by (Edori and Edori 2021) in Orashi river. The moderately alkaline value observed in this study does not portend danger for the aquatic organisms and human, since it is within the permissible limit. Similarly, the mean of water temperature followed the same pattern as the P^H , and no statistical difference ($p > 0.05$) was observed across the sampling months, but the values recorded in station 1 and 2, were significantly different ($p < 0.05$) from the values observed in station 3 and 4. The observable spatial variation could be due to anthropogenic pressure around the stations (Pareek *et al.*, 2018).

The mean temperature observed in this study is consistent with the results previously reported by other researchers (Okey-Wokeh *et al.*, 2021). Undoubtedly, the water temperature mean falls within the WHO (2017) permissible limit for domestic water use like drinking, aquaculture and other purposes. The values of turbidity presented in Table 1 and 2, revealed station 3 (STN₃) showed significant difference ($p < 0.05$) from station 4 (STN₄) but showed no significant difference from STN₁ and STN₂. The mean turbidity recorded in the study was significantly higher than the value provided by (World Health Organization; 2017). Edori and Aniekan (2021), reported of similar result in Niger delta water which was attributed to runoffs and re-suspension of particles. The mean of salinity in water samples revealed the existence of spatial variation in station 1 (STN₁) with significant difference ($p < 0.05$) from other stations. This finding is consistent with the values recently reported from Orashi river water (Okwodu *et al.*, 2022). The values of salinity obtained in the study indicate that Orashi river is purely a freshwater ecosystem.

The Biochemical Oxygen Demand (BOD) values observed in this study were found to be within 2 to 5 mg/l recommended by both National and International Organisations. Similar results were reported previously in some aquatic environment in Niger delta (Okey-Wokeh *et al.*, 2020, Okwodu *et al.*, 2022), but varied with that of Edori and Edori (2021) that reported of a higher BOD in Orashi river. There was no spatial and monthly variation ($p > 0.05$). The BOD result proves that the river water is good for drinking and can comfortably sustain other aquatic organisms.

CONCLUSION

Generally, the results of physicochemical parameters in this study were found to be within national and international standards for drinking water, which depict Orashi river water quality to be good and suitable for domestic, aquaculture, and other agricultural uses. To maintain the river water quality within the threshold suitable for human health, there must be close monitoring of human activities that are capable of deteriorating the water quality of Orashi river by all stakeholders.

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FISHING BIODIVERSITY AND ENTERPRISES AT RIBADU LAKE, ADAMAWA STATE, NIGERIA.

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ABSTRACTS

This study assesses the fishing activities at Lake Ribadu, Adamawa State, Nigeria. The study was conducted from May to August, 2017 to determine the demographic profile of fishers, species of fish's harvested, economic impact of fishing on the community and the contribution of other livelihood activities to overall economy of the fishers. Hausa migrant fishers constitute 35% at the community, with 90% illiterate level at the fishing community. Highest gear utilization is show with Set net with 35% and least was Gill net with 3%. Most of the fishers fall within age group of 30-50 years with all of them within range years of experienced of 20-40years. Highest weight of fish was caught with a ranged of 3-4.9kg comprising of 60.8kg per catches and the abundant species catch was clarias which made up of 28.4kg. A total of 139.9kg of fish was recorded during the study of 40 fishers in the community showing average catch per fisher was 3.5kg. The average economic impact performance ranking of 2007.8 shows that the economy of fishing activities at the community was average at subsistence level. Four activities were identified to improve the livelihoods of the fishers, with farming showing highest of 55% and least trading with 4%."Gurchace" is practiced as a tool for traditional co-management system at this community. These suggested that, Lake Ribadu was poorly managed by government and fishers so as to sustain the availability of aquatic natural resources in comparison with the catches per efforts of the average fishers.

Keywords: Biodiversity, Enterprises, Fishing, Lake, Ribadu

INTRODUCTION

Poor management and over exploitation decrease in resources availability, does not only resulted in poor income, but also in wellbeing of fishing households and the community. Since fishing communities in Nigeria are generally still far from development, the fishers are categorized among the poorest of the poor (Araoye; 2002 and William; 2007). This important sector has been faced with several constraints, such as fishers having low income, no properties, weak political influences (Neiland *et al*; 2005). The management of fisheries resources is central in addressing the fishers' vulnerability and improving their livelihoods. This necessitated several approaches for resources management over the years by government, donor agencies and non-governmental organizations, with more recent advocacy on concept of livelihood and diversification in order to reduce fishing effort and improve their wellbeing (Tafida *et al*; 2011). There is need to look at the contribution of each livelihood activities in the communities and their best combination in order to strengthen the efforts of the fishers in diversifying their livelihood to achieve self-sufficiency, improve standard of living and enhance rural community development in those areas. Upper River Benue being the second largest inland fishery in North Eastern Nigeria after Chad Basin (Baka.,2015) has suffered deflation of fisheries resources which attest to the above facts, considerable literature have agreed with the decline trend over the years (Raji and Ovie; 2007). Poor fisheries and non- responsible fishing activities in both traditional and modern systems; has reduced the livelihood of the fishing communities along the region. The poor fishers in trying to meet the demand of domestic needs often over exploit the aquatic resources by the

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use of destructive fishing gears and adoption of unwanted (obnoxious) fishing methods, thereby destroying the dynamics of sustain fish population (Raji *et al*; 2012 and Allan *et al*; 2005).

Materials and Methods

Study Area

The study area is located within latitude 9.12 to 16.46°N and longitude 12.28 to 12.40°E. The Lake Ribadu is found in Fufore Local Government Area, which providing the immediate fish supply to the Fufore communities, state and beyond.

Data Collections and Analysis

The data was collected from the months of February to April, 2015. The instrument for the data collection of this study was structured questionnaire; the validity and reliability of the items in the questionnaire were tested and found valid and reliable for this type of research study. Fish species relative abundance were analyzed using descriptive statistical tools to calculate frequency and simple percentage.

Results and Discussion

Table 1 present the results for ethnic groups, educational level, language spoken, aged group, year of experienced and other activities engaged by the fishers. Bwatiye had 20%, while Jukun and Hausa had 62.5% and 17.5% respectfully. The education level of the fishers at Ribadu, uneducated comprising of 90%, while those with GCE and FSLC with 5% respectively. The various languages spoken shows that Hausa is the major language with 35% followed by Fulbe 25%, and least is English 5%. The age group of the fishers indicated that those in age group 40-50years has the highest value with 45%, while the least was recorded in group ranged of 21-30years with 5%. The years of experience in fishing of the fishers, those having 21-40 years in fishing has 65%, followed by those within the range of 1-20 years' experience with 35% and livelihoods activities involved by the fishers apart from fishing, 55% of the fishers were engaged in farming, 35% in livestock rearing and 10% in trading being the least. The languages spoken around the fishing lakes are Fulbe, Bwatiye, Jukun, Agatu, Hausa and English, Composition at this village showed Hausa language to be highly spoken, indicating that it's a mother tongue language at this part of the country. The percentage composition of those that attended formal education at Ribadu was just 10% indicating that education is very poor at the fishing community and that the children of the fishers do not even attend primary schools due to their parent allowing them to assist in fishing, this agreed with the observation of Fregene, (2003) and Afolayan, (2004). The composition of those that receive formal education at the fishing community have the following percentages, general certificate of education (GCE) 5%, first school leaving certificate (FSLC) 5% showing that there is low level of educated. The aged range and year of experience of the fisher's shows that the age range of 41.50years and 21-40 years of experience significantly has the highest percentages composition which were 35% and 65% respectively. This also agreed with the observation of Tafida *et al*. (2011) who reported people at this age are more engaged in fishing activities. Fishing in combination with other fisheries activities show a dynamic effect on the standard of living of those that are dwelling around the lakes. Some of the other activities that depend on fishery are the fish processor, fish marketers, net menders from already fabricated materials purchased somewhere and the carpenters that construct fishing boats and paddles, and this was also reported by Tafida *et al*; (2011) and Ladu *et al*; (2013). The overall composition of the activities revealed that farming continuous to feature as a major source of income across the fishing communities of the lake with 55% and same was reported by Tafida *et al*, (2011).

Table 1: Demographic information of Fishers of Lake Ribadu between Februarys to April, 2015

Ethnic Groups	Number of Fishers	Percentage Composition
Hausa	25	62.5
Jukun	7	17.5
Bwatiye	8	20.0
Total	40	100
Education Level		
GCE	2	5.0
NCE	0	0.0
FSLC	2	5.0
Uneducated	36	90.0
Total	40	100

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Language Spoken		
Agatu	4	10.0
Bwatiye	5	12.5
English	2	5.0
Fulbe	5	12.5
Hausa	14	35.0
Jukun	10	25.0
Total	40	100
Age Range		
11-20	0	0.0
21-30	2	5.0
31-40	15	37.5
41-50	18	45.0
51-60	5	12.5
61-70	0	0.0
Total	40	100
Years of Experience		
1-20	14	35.0
21-40	26	65.0
41-60	0	0.0
Total	40	100
Other Activities		
Trading	4	10.0
Farming	22	55.0
Livelihood	14	35.0
Civil Servant	0	0.0
Total	40	100

Table 2 shows the fishing gears used, this ranged from Set net, gill net, Cast net, Drag net, Hooks and Traps. Set net recorded highest utilization value with 35%, followed by Cast net with 20%, while the least utilized gear was Gill net with only 3%. There are six types of gears used at Lake Ribadu, include Set nets, Gill nets, Traps, Drag nets, Cast nets and Hooks, The traps include Malin, Ndurtu, Gura of varying shapes and sizes. All these gears are produced based on traditional designs manufactured locally with the use of modern fabricated materials like twines or ropes imported from somewhere. The 19% use of traps at Ribadu may be due to presence of vegetation around the lake. The 35% and 20% of Set and Cast nets usage at Ribadu is recorded due to the concentrated large surface area of water free from vegetation that allows easy operations of these gears. The low percentages usage of gill net is because of the fact that no enough space to operate it due to disturbances from the fishers throwing Cast Nets and Drag Nets, which was against the recommended mesh size (76 millimeters) to be used as promulgated by Adamawa state edict No 5 of 2003 dated 30/12/2003 (Wildlife caps; 2003). Thus the fishers use the gear in contrast with the law since it will give low yield or no catch at all (Silvano and Begossi; 2001), thus most fishers react by reducing their fishing net mesh size by moving into other like, Drag net, Set net, Traps, where the fishers use less smaller mesh size (Ekundayo *et al*; 2014).

Table 2: Gear Utilization of Lake Ribadu between Februarys to April, 2015

Types of Gears	Number of fishers	Percentage Composition
Set Net	28	35.0
Gill Net	2	3.0
Cast Net	16	20.0
Drag Net	10	13.0
Hooks	8	10.0

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Traps	15	19.0
Total	79	100

Table 3 shows the weight catch and their corresponding monetary value per week. The highest total catch was recorded at week three with 30%. While the least was at week three with 17%. The monetary value of available fish species observed during the study are also indicated that *clarias* has the highest with 35.4%, while the least was *hydrocynus* with 2.5%. Based on the result obtained the highest weight of fish catch was recorded at week three with 42kg. Since financial status of each fisher will depend on his daily average catch, it was shown through study that based on the sampled fishers' number per fishing village; Ribadu has average catch of 3.5 kg per fishers per day, this result to daily amount of ₦1574 per fisher in a day. The low average catch of 3.5 kg per fisher in Ribadu supports the early works of Thomas, (1996) that the normal catches per fisher per day in African flood plains hardly exceed 4kg per fisher per day. Also as a result of the lake at River transit downstream an impoundment of Lagdo dam on the River Benue, its performances is usually also low since the impoundment will reduce the inundated flood plains, alters the natural river flow and retains the nutrients upstream from the barrage and this effect reduces fish production downstream (Petrere and Ribeiro; 1994, Muller and Gavaut; 1976).

Table 3: Weight and monetary value of fish caught per week and Monetary Value of Commercially Available Fish Species of Lake Ribadu between Februarys to April, 2015

Weeks	Weight(kg)	Monetary Value(N)	Percentage Composition
1	27.6	12,420	20.0
2	41.7	18,765	29.8
3	42.0	18,900	30.0
4	28.6	12,870	20.2
Total	201.4	62,955	100
Species	Weight(kg)	Monetary Value(N)	Percentage Composition
Synodontis	3.3	1,485	2.6
Tilapia	34.0	15,300	27.0
Clarias	85.7	38,565	68.0
Lates niloticus	1.8	810	1.4
Schilbe	1.2	540	1.0
Total	126	56,700	100

Table 4 shows frequency of fish species caught, *clarias* appear 15 times, while least was *hydrocynus* appear once. The conditions responsible for these threatened species may vary either as a result of overfishing due to the demand or affected by macrophytes due to ecosystem degradation cause by the persistent floods from Lagdo dam yearly (Ladu *et al*; 2013; Ekundayo *et al*; 2014). Since the lake are situated on the flooded wetland plains of Upper River Benue with numerous tributaries forming linkages for entrance and exit of new and common fishes such as *Heterotis*, *Citharinus*, *Heterobranchus*, *Mormyrus*, *Hydrocynus*, and *Gymnarchus niloticus* may be carried away by environmental degradation like floods which has been so common over the years from Lagdo dam (Idodo-Umeh; 2003; Ladu *et al*; 2013).

Table 4: Frequency of Fish Specie Caught

Species	Frequency	Percentage Composition
Synodontis	3	7.5
Tilapia	13	32.5
Clarias	15	37.5
Lates niloticus	3	7.5
Hydrocynus	1	2.5
Protopterus	3	7.5
Heterotis	2	5.0

Total	40	100

Table 5 shows the economic impact of fishing on the population, indicating that the catch range of 3-3.9 kg was highest with monetary value of N27, 360.00, and the least was in range 5-abovekg having monetary value of N16, 560.00. this study shows that the number of fishers within each catch range is higher in 0-2.9 kg with 19 fishers, followed by 3-3.9kg with 16 fishers and 5-abovekg with 5 fishers, this progressive increase in monetary based on the total catch range may probably be due to the use of the size, types, selectivity of fishing gears and effort being applied by the fishers (Tafida *et al*; 2011). Study also revealed that no matter how large the numbers of fishers within a particular group of catch range, their performance grading are the same. The unsuccessful nature of fisheries management in lakes downstream Lagdo dam, and the eventual dwindling of the resources by the fishers have placed more problems to accepting fishing as a viable livelihood option in most of the fishing communities of this lake (Neiland; 2000; Tafida *et al*; 2011).

Table 5: Economic Impact of Fishing on the Population of Fishers

Catch Range(kg)	Total Weight(kg)	Number of Fishers	Monetary Value(N)	Monetary Performance(N)	Performance Ranking
0-2.9	42.3	19	19,035	1001.5	Below Ave.
3-3.9	60.8	16	27,360	1710.0	Average
5- Above	36.8	5	16,560		
Total	201.4	40	62,955	3312.0	Good

CONCLUSION

In conclusion, Government, fisheries and water management partners and the fishing community leaders had not done well to sustain the availability of the natural resources, more especially the fisheries resources in the water body.

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DETERMINATION OF PHYSICO-CHEMICAL PARAMETERS OF ST. NICHOLAS RIVER, BAYELSA STATE, NIGER DELTA, NIGERIA.

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ABSTRACT

The Physico-chemical parameters of St. Nicholas River were determined from October, 2020 to September, 2021. Three sampling stations were identified and used throughout the duration of the studies. They were Meinmokiri, Ebierewo-bugo and Egeinkiri sampling stations. The mean values of the Physico-chemical parameters of water at the three sampling stations are as follows, temperature was $29.98 \pm 0.55^{\circ}\text{C}$, dissolved oxygen (DO); $11.89 \pm 0.33\text{mg/L}$, Biochemical Oxygen Demand (BOD); $2.06 \pm 0.26\text{ mg/L}$, Salinity; $16.80 \pm 2.06\text{ PPT}$, Conductivity; $27.54 \pm 3.03\mu\text{S/cm}$, Total Dissolved Solids (TDS); $9.44 \pm 0.50\text{mg/L}$, pH; 7.41 ± 0.14 , Water Depth; $0.58 \pm 0.06\text{m}$, Transparency; $27.27 \pm 0.03\text{cm}$ and Water Velocity; $54.79 \pm 5.71\text{m}^3/\text{s}$. These physicochemical parameters values are comparable with other water bodies in the Niger Delta indicating contaminated waters. The contamination was caused by anthropogenic activities in terms of parameters assessed, therefore mitigation should be put in place for biodiversity conservation and sustainability of the ecosystem.

Key Words: Physico-chemical, St. Nicholas Rivers, Bayelsa State, Niger Delta, Nigeria.

INTRODUCTION

The importance of the Physico-chemical parameters of water cannot be overemphasized as they are required to sustained biodiversity in the aquatic environment including plankton and fish. The Physico-chemical parameters undertaken in this study were; temperature, dissolved oxygen, biochemical oxygen demand, salinity, conductivity, total dissolved solids, pH, transparency, water depth and water velocity.

Temperature is defined as the degree of hotness or coldness in a body. Temperature is measured using a good mercury-filled Celsius thermometer (ALPHA, 1995). According to Singh et al. (2013) among the various physical factors influencing the aquatic environment, temperature is of great importance and it plays a critical role in the life of aquatic poikilotherms.

Dissolved oxygen is one of the key factors of aquatic life. Oxygen is more important to aquatic than to terrestrial life. This is because oxygen has a low solubility in water and is often a limiting factor for life in water. Oxygen concentration in water is controlled by four factors: photosynthesis, respiration, exchanges at the air water interface, and supply of water to the water body or pond (Krom et al., 1989; Erez et al., 1990). Biochemical oxygen demand is used as a measure of the quantity of oxygen required for oxidation of biodegradable organic matter present in water samples by aerobic biochemical action. Ademoroti (1996) noted that oxygen demand of waste waters is exerted by three classes of materials: Carbonaceous organic materials usable as source of food by aerobic organisms, Oxidable nitrogen compounds which serve as food for specific bacteria (e.g. *Nitrosomonas* and *Nitrobacter*) and Chemical reducing compounds e.g., Fe^{2+} , SO_3^{2-} and S^{2-} which are oxidized by dissolved oxygen.

As a basic definition, salinity is the total concentration of all dissolved salts in water (Wetzel, 2001). The dissolved salt dissociates into electrolytes to form ionic particles with a positive and negative charge. As such, Salinity is a strong contributor to conductivity.

Conductivity is the measure of water capability to pass electrical flows. This ability is directly related to the concentration of ions in the water (EPA, 2012). These conductive ions come from dissolved salts and inorganic materials such as alkalis, chlorides, sulphides and carbonates compounds (Miller et al., 1988).

pH is a determined value based a defined scale. This means that pH of water is not a physical parameter that can be measured as a concentration or in a quantity. Instead, it is a figure between 0 and 14 defining how acidic or basic a body of water is along a logarithmic scale (Merrian-Webster, 2013). The lower the number, the more acidic the water is. The higher the number the more basic it is. A pH of 7 is considered neutral.

Water Depth is an important index of hydrology which influences other environmental factors such as under water light intensity, temperature variation and nutrient content (Nannan et al., 2017). Changes in all of these factors can affect the growth and distribution of submerged macrophytes and structure of communities.

Water transparency is measured with a Secchi disk. A Secchi disk is a metal disk, about 8 inches in diameter that is lowered into the water on a cord. The depth that the Secchi disk can no longer be seen through is the water is the Secchi disk depth and that is the measurement of the water transparency (Detroit Lakes Laboratory (2022)

Total dissolved solids (TDS) combine the sum of all ion particles that are smaller than 2 microns (0.0002 cm) (EPA, 2012). This includes all of the disassociated electrolytes that make up salinity concentrations, as well as other compounds such as dissolved organic matter. TDS can include organic solutes (such as hydrocarbons and urea) in addition to the salt ions (Thompson et al., 2006).

Water movement has long been acknowledged as one of the prime factors regulating the growth and distribution of submerged aquatic plants in streams and rivers. Current velocity is the most studied determinants of foraging behaviour for juvenile salmonids. Aggressiveness and foraging rate (Grant & Noakes, 1988) as well as local point depth (Hezelton & Grossman, 2009).

MATERIALS AND METHODS

Study Area

The study was carried out in St. Nicholas River, Niger Delta and its adjoining mangrove creeks situated along the river. The St. Nicholas River is one of the major estuaries of the Niger River. It is situated between longitude 4° 23' E and 6° 21' E and latitude 4°31' N and 4° 56' N (Fig. 1). The Stretch of the river is about 17km. The vegetation is predominantly mangrove, *Rhizophora racemosa*, *Rhizophora mangle*, Sparsely *Avicenia africana* and normal forest vegetation at the coastline

The Physico-chemical parameters such as temperature, salinity, pH, conductivity, total dissolved solids (TDS), dissolved oxygen (DO) water velocity and water depth, were measured in situ with mercury

thermometer (Mercury in glass thermometer), hand held digital Salinometer (Model AR8012), pH meter (Model PH-009 (1)), digital conductivity tester (Model AR8011), TDS meter (Model AR8011), digital water velocity meter (Model PF LV550), digital depth finder (Model SD-5) and dissolved oxygen meter (Model OM-51-10) respectively.

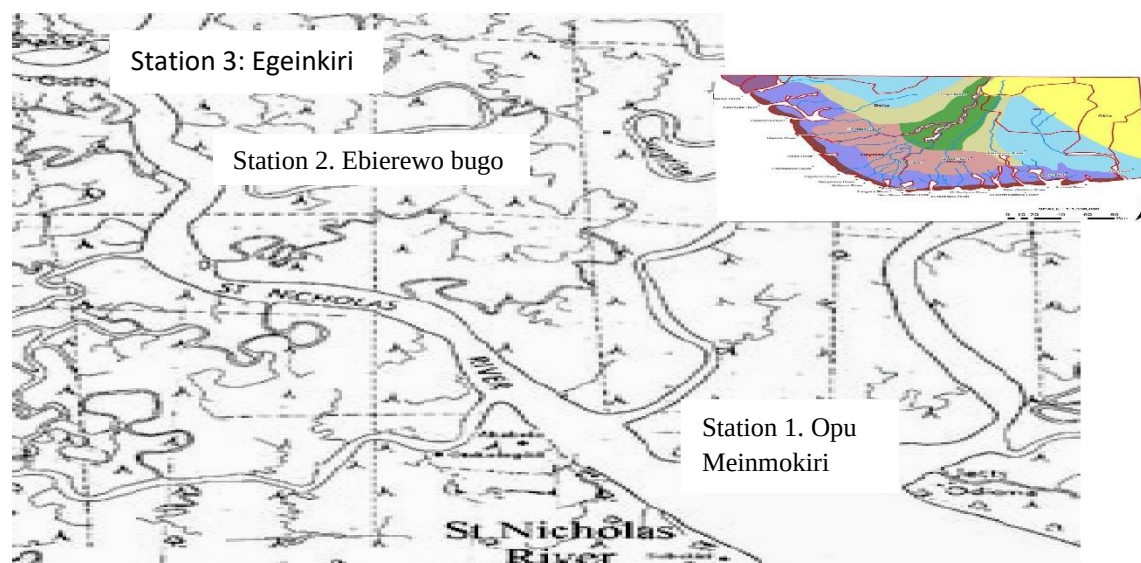


Fig.1: Map showing the St. Nicholas River, the study Area.

Source: Akani *et al.* (2010).

Results and Discussion

The mean and standard error values for monthly and seasonal variations of Physico-chemical parameters of water sampled from October, 2020 to September 2021 on the three sampling stations are presented on Table1 and table 2.

Table 1: Mean values for Physicochemical Parameters of water at the three sampling stations from October, 2020 to September, 2021 in St. Nicholas River, Bayelsa State, Nigeria

Parameters	Sampling Stations			Mean $\pm$ S. E
	1	2	3	
Temperature ($^{\circ}\text{C}$)	29.77 ± 0.54	30.19 ± 0.54	29.98 ± 0.56	29.98 ± 0.55
D O (mg/L)	11.97 ± 0.37	11.86 ± 0.31	11.85 ± 0.31	11.89 ± 0.33
B O D (mg/L)	2.00 ± 0.31	2.08 ± 0.24	2.11 ± 0.23	2.06 ± 0.26
Salinity (PPT)	21.50 ± 2.26	15.41 ± 1.86	13.48 ± 2.09	16.80 ± 2.06
Conductivity ($\mu\text{S}/\text{cm}$)	35.59 ± 2.66	24.19 ± 3.41	22.85 ± 3.01	27.54 ± 3.03
T D S (mg/L)	10.41 ± 0.12	9.27 ± 0.58	8.65 ± 0.81	9.44 ± 0.50
pH	7.48 ± 0.12	7.37 ± 0.14	7.38 ± 0.16	7.41 ± 0.14
Water Depth (m)	0.42 ± 0.06	0.7 ± 0.08	0.58 ± 0.05	0.58 ± 0.06
Transparency (cm)	21.33 ± 0.01	30.67 ± 0.03	30.00 ± 0.04	27.33 ± 0.03
Water Velocity (m^3/s)	47.75 ± 5.28	47.75 ± 5.28	55.88 ± 5.37	54.79 ± 5.71

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1 = Meinmokiri, 2 = Ebierewo-bugo, 3 = Egeinkiri; S.E = Standard Error, D O = Dissolved Oxygen, B O D = Biochemical Oxygen Demand, T D S = Total Dissolved Solids, pH = Power of Hydrogen.

Table 2: Comparison of Mean values of Physicochemical parameters of water for Dry Season and Wet Season from October, 2020 to September, 2021 in St. Nicholas River, Bayelsa State, Nigeria.

Parameters	Dry Season $\pm$ S. E	Wet Season $\pm$ S. E	Mean $\pm$ S. E
Temperature ($^{\circ}$ C)	30.35 $\pm$ 0.38	29.28 $\pm$ 0.36	29.82 $\pm$ 0.37
D O (mg/L)	11.68 $\pm$ 0.38	12.10 $\pm$ 0.30	11.89 $\pm$ 0.34
BOD (mg/L)	1.98 $\pm$ 0.47	2.15 $\pm$ 0.29	2.07 $\pm$ 0.38
Salinity (PPT)	15.02 $\pm$ 2.28	18.58 $\pm$ 2.70	16.80 $\pm$ 2.49
Conductivity (μ S/cm)	25.02 $\pm$ 4.39	30.07 $\pm$ 4.12	27.55 $\pm$ 4.26
TDS (mg/L)	7.64 $\pm$ 0.62	9.62 $\pm$ 0.50	8.63 $\pm$ 0.56
pH	7.17 $\pm$ 0.11	7.77 $\pm$ 0.14	7.47 $\pm$ 0.13
Water Depth (m)	0.54 $\pm$ 0.56	0.61 $\pm$ 0.08	0.58 $\pm$ 0.32
Transparency (cm)	29.54 $\pm$ 0.05	25.00 $\pm$ 0.03	27.27 $\pm$ 0.04
Water Velocity (m^3/s)	50.11 $\pm$ 8.83	49.43 $\pm$ 4.48	49.77 $\pm$ 6.66

S.E = standard error, D O Dissolved Oxygen, TDS = Total dissolved Solids pH = Power of Hydrogen

The mean Temperature in this study as shown on table 1 is higher than 25.433 $\pm$ 0.218 $^{\circ}$ C reported in Amassoma by Ogamba *et al.* (2015) and 27.250 $^{\circ}$ C reported in Wilberforce Island, by Agedah *et al.* (2015). The dry and wet season shown on table 2 recorded 30.35 $\pm$ 0.38 $^{\circ}$ C and 29.28 $\pm$ 0.36 $^{\circ}$ C which is relatively comparable with reports of temperature in the range of; 28.7 – 30.5 $^{\circ}$ C (dry season) and 27.3 – 29.3 $^{\circ}$ C (wet season) in Epie creek in Yenagoa metropolis, Bayelsa State (Izonfuo & Bariweni, 2001), 30.22 $^{\circ}$ C and 29.88 $^{\circ}$ C for dry and wet season respectively at Minichnda Stream (Allison & Otene, 2012), 26 - 27 $^{\circ}$ C from River Olosun, Ibadan, Oyo State (Ewa *et al.*, 2014), but slightly higher than 26.9 – 28.7 $^{\circ}$ C, 26 $^{\circ}$ C value at Tombia Bridge Construction across Nun River (Seiyaboh *et al.*, 2013), 26.77 - 28.07 $^{\circ}$ C and 26.37 - 27.13 $^{\circ}$ C in dry and wet seasons in (Seiyaboh *et al.*, 2016). The slight variation in temperature from this study with previous studies could be attributed to the time of sampling and environmental condition as well as the relative humidity of the days (Ogamba *et al.*, 2015). Although there is no regulatory limit for temperature; however, standard temperature that sustain life should be ambient; temperature variability might encourage the invasion of alien species, or adverse effect to biodiversity (Angaye & Mileyepa, 2015).

The mean Dissolved oxygen DO in this study as shown on table 1 is higher than 10.200 $\pm$ 0.283 mg/l at Igbedi, 4.8mg/l – 7.2mg/l (Seiyaboh *et al.*, 2013), 9.07-19.52mg/l for Efi Lake (Angaye, & Mileyepa (2015), 5.0 – 7.92 mg/l for Kolo Creek (Aghoghovwia & Ohimain, 2014), and lower than 14.225 $\pm$ 0.263mg/l at Ogobiri which were reported along the river Nun axis (Agedah *et al.*, 2015). The dry and wet season shown on table 2 recorded 11.68 $\pm$ 0.38 mg/l and 12.10 $\pm$ 0.30 mg/l which is relatively higher when compared to 5.80 – 7.60 mg/l in dry season and 11.10 – 15.73 mg/l in wet season (Seiyaboh *et al.*, 2016), 1.38 – 9.06 and 1.76 – 5.68 mg/l for dry and wet seasons of Epie Creek respectively (Izonfuo *et al.*, 2001). Extremely low DO can be lethal to aquatic biota (Ezekiel *et al.*, 2011), especially in cases lower than 2.0mg/l (Ohimain *et al.*, 2013; Atobatele *et al.*, 2008).

The mean Biochemical oxygen demand BOD in this study as shown on table 4.1.1. The dry and wet season shown on table 2 recorded 1.98 $\pm$ 0.47 and 2.15 $\pm$ 0.29 and were lower compared to biological oxygen demand (BOD) for dry season (12.58 - 41.17 mg/l), and wet season (6.77 – 8.10 mg/l) at Orashi River (Seiyaboh *et al.*, 2016). The lower BOD recorded could be due to low levels of organic waste. Omotoso *et al.* (2015), reported that higher BOD is due to increased degradable organic waste.

The mean Salinity in this study as shown on table 2 is higher than 7.25 mg/l in Amassoma River in 2005 reported by (Nyananyo *et al.*, 2007), 0.000 – 0.017 mg/l, at Amassoma River (Ogamba *et al.*, 2015), 0.010 ‰ in 2007 reported by (Agedah *et al.*, 2015), 0.01 mg/l and 0.04 mg/l by (Allison & Otene, 2012). The higher concentration of salinity could be due to proximity to the adjacent Gulf of Guinea.

The mean Conductivity ($\mu\text{S/cm}$) in this study as shown on table 1 is lower than $33.167 - 68.000 \mu\text{S/cm}$ reported by (Ogamba *et al.*, 2015), but comparable to $28 \mu\text{S/cm}$ by (Agedah *et al.*, 2015). The dry and wet season shown on table 2 recorded $25.02 \pm 4.39 \mu\text{S/cm}$ and $30.07 \pm 4.12 \mu\text{S/cm}$ which is lower than $78.33 - 89.33 \mu\text{S/cm}$ (dry season) and $47.73 - 54.00 \mu\text{S/cm}$ (wet season) from Epie Creek in Yenagoa metropolis (Izonfuo & Bariweni, 2001), $105.05 \mu\text{S/cm}$ and $169.32 \mu\text{S/cm}$ during dry and wet season respectively from Minichnda Stream (Allison & Otene, 2012). The magnitude of conductivity is a useful indication of the total concentration of the ionic solutes.

The mean T D S (mg/L) in this study as shown on table 1 is comparable to $6.77 - 12.80 \text{ mg/l}$ in Orashi River (Seiyaboh *et al.*, 2016). The dry and wet season shown on table 2 recorded $7.64 \pm 0.62 \text{ mg/L}$ and 9.62 ± 0.50 which is lower compared to Kolo Creek which ranged from $41.5 - 51.0 \text{ mg/l}$ (Aghoghovwia and Ohimain, 2014), Amassoma and Igbedi axis of River Nun were 28.180 ± 0.048 and $32.550 \pm 0.666 \text{ mg/l}$ respectively (Agedah *et al.*, 2015) Epie Creek TDS had values of $55 - 62$ and $33 - 37.33 \text{ mg/l}$ in dry and wet seasons respectively (Izonfuo & Bariweni, 2001), while Tombia axis of the River Nun was $62.1 - 67.9 \text{ mg/l}$ for (Seiyaboh *et al.*, 2013).

The mean pH in this study as shown on table 4.1.1 is comparable to $6.910 - 7.350$ at Amassoma by (Ogamba *et al.*, 2015). The dry and wet season shown on table 2 recorded 7.17 ± 0.11 and 7.77 ± 0.14 which is higher than 5.25 and 5.93 at dry and wet season from Minichnda Stream (Allison & Otene, 2012) but comparable to $6.5 - 6.9$ from River Olosun, Ibadan, Oyo State (Ewa *et al.*, 2014), $7.4 - 7.57$ (dry season i.e. December, January and February) and $6.9 - 7.33$ (wet season i.e April, May and June) of Epie Creek (Izonfuo and Bariweni, 2001) and $7.4 - 7.5$ at Tombia Bridge Construction across Nun River (Seiyaboh *et al.*, 2013).

The mean Water Depth (m) in this study as shown on table 1 to be $0.58 \pm 0.06 \text{ m}$. The dry and wet season shown on table 2 recorded $0.54 \pm 0.56 \text{ m}$ and $0.61 \pm 0.08 \text{ m}$. This might suggest the species can be good candidates for culture as they are accessible in shallow waters. The mean Transparency (cm) in this study as shown on table 1 to be $27.33 \pm 0.03 \text{ cm}$. The dry and wet season shown on tables 2 recorded $29.54 \pm 0.05 \text{ cm}$ and $25.00 \pm 0.03 \text{ cm}$. This indicates moderate light penetration. The mean Water Velocity (m^3/s) in this study as shown on table 1 to be $54.79 \pm 5.71 \text{ m}^3/\text{s}$. The dry and wet season shown on table 2 recorded $50.11 \pm 8.83 \text{ m}^3/\text{s}$ and $49.43 \pm 4.48 \text{ m}^3/\text{s}$.

CONCLUSION

This study was carried out at St. Nicholas River in Bayelsa State, Niger Delta of Nigeria to obtain basic information on Physico-chemical parameters. The result showed that Physico-chemical parameters of the River which is essential to the sustenance of biodiversity, the environment and public health were within the range of parameters reported by researchers for drainage systems in the Niger Delta.

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ASSESSMENT OF THE SPATIAL DISTRIBUTION AND PHYSICO-CHEMISTRY OF THE MACROBENTHIC FAUNA OF NKORO CREEK, NIGER DELTA REGION OF NIGERIA

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ABSTRACT

Macrobenthic fauna of the mud flats of the Nkoro Creek was studied monthly between July 2017 to October 2017. Three stations were delineated. Samples were collected for sorting, identification counting and analysis for abundance, species evenness and species richness. Thirteen taxa of macrobenthos were collected

from 4 Phyla, 5 Classes, 11 Families and 315 individuals. Across the three stations, *Alpheus pontederlae* and *Nereis* sp. were evenly distributed while *Tympanotonus fuscatus*, *Sesarma elegans* and *Palaemonetes africanus* were clustered at Stations III, II and II respectively. The pH of the Creek was between 6.8 (Station II) to 7.6 (Station III) with a salinity range of 9.5 ‰ at Station III to 10.7 ‰ at Station II. Meanwhile, BOD and temperature increased progressively from Station I to Station II. Temperature ranged between 26.2°C to 28.1°C and BOD 3.1mg/l to 4.6mg/l. Dissolved oxygen was highest at Station II (7.9mg/l) and least at Station I (7.2mg/l). Station I recorded highest in species richness with 12 taxa while station III had least (10 taxa). Species abundance across the three stations were 73 (23%) at Station I; 134 (43%) at Station II and 108 (34%) at Station III. The diversity indices revealed that Station I had the highest Simpson's index (0.173) and least in Margalef's index (0.823) and a species evenness (0.814); Station II recorded highest in Shannon-Wiener index (2.17), Margalef's index (0.866) and species evenness (0.905) while Station III had the least value in the Shannon-Wiener index (2.001) of species diversity. Since index of species diversity is considerably high, it can be inferred that the Nkoro Creek supports benthic macro-invertebrates and is less polluted. This study recommends a further study on the relationship between substratum and macroinvertebrate distribution in the Nkoro Creek.

Keyword: Macrobenthic fauna, diversity, physico-chemistry.

INTRODUCTION

Lotic water is a trans-boundary resource flowing across territories (Woke and Aleleye-Wokoma, 2014), yet retaining distinct properties peculiar to a settlement. As water takes its course from the ocean through the seas and rivers to the tributaries and creeks, the physico-chemical parameters become altered (Verma and Agarwal, 2008) significantly. The alteration of the physico-chemistry of water along its course is due to the influx of marine water from oceans with fresh water from inland waters and run-off. These changes in environmental conditions of a water body affect the biotic community supported (Unanam and Akpan, 2006). Biotic communities are however, to some degrees affected by the substratum on which they had contact with (Ansa, 2005). Primary productivity and species diversity are highest in mud flat, comprised mainly of silt than those of sandy substratum (Sheppard *et al.*, 2010). The alteration of the physico-chemistry of water may be natural, man-induced or from the activities of the aquatic organisms. Natural effects can be affected by precipitation or the mixing of freshwater and marine water at the estuaries while man-induced effects are evident in the disposal of wastes which can be industrial or agricultural, the construction of barriers like dams for power generation and dredging activities. Living organisms also play a role through decomposition activity of micro-organisms though this is to a lower extent. According to Meybeck *et al.* (1996) water quality assessment is majorly of three components: physical, chemical and biological components. The traditional and common approach assesses the physical and chemical properties of the water to determine the water quality of an area (Chen *et al.*, 2019). This is the physico-chemical parameter approach. The biological approach (Silvia *et al.*, 2016) studies the aquatic biota, their ecology, spatial distribution, dynamics and interactions between and within species to give reliable information on the life sustaining capacity of such water, hence, its health.

Macrobenthic fauna encompasses all organisms usually animals living on, in or near the bed of a water body that are visible to the naked eye (Wang *et al.*, 2021). Macro-benthic communities play important roles in ecosystem processes like detoxifying pollution, recycling nutrients as well as secondary production and burial of organic matter (Bassey *et al.*, 2020). To researchers, macrobenthos are useful following their linking the aquatic food chains (Haque *et al.*, 2021), short life spans (Woke and Aleleye-Wokoma, 2014), sensitivity and rapid response to alterations in environmental condition (Bassey *et al.*, 2020), and mobility in which most are sessile, burrowers or slow moving (George *et al.*, 2010). Hence, they provide information relevant to a study area at a given time (Ravera, 2000). Dynamics in the benthic communities and distribution of aquatic species is to a large extent affected by environmental conditions (Anyanwu and Jerry, 2017). The following abiotic factors were listed by Anyanwu *et al.* (2019) as predominant in affecting macrobenthic populations in their order of importance: current or speed of water, water temperature, level of oxygen and salinity, acidity, hardness and general water chemistry. Of both physical and chemical factors, Mills (2002)

agreed that the chemistry of the water is an important factor in the distribution of aquatic organisms. However, substratum also plays a significant role in the distribution (Ansa, 2005).

Parker and Voshell (2003) noted that benthic assemblages are primarily affected by salinity and temperature while the substratum is a secondary factor. However, dissolved oxygen concentration and biochemical oxygen demand in addition to the primary factors reflects on species compositions, abundance, biomass and distribution patterns (Humood, 2011). The Nkoro creek is grossly understudied though it is situated in the Andoni flats receiving both from the Opobo River and Bonny/Andoni River systems and emptying into Ogoni at the Iyaba market creek and lower reaches of the Barigwa Creek. Therefore, there is little or no information available to researchers in the study of the assessment of water quality and the ecology and spatial distribution of macrobenthic fauna in this area.

MATERIALS AND METHODS

Description of Study Area and Sampling Stations

The Nkoro Creek, where this study was undertaken is a brackish water creek situated at the lower reaches of the Andoni mud flats of the Andoni/Bonny River in the Niger Delta region of Nigeria. The mouth of the creek extends to the Opobo River. The flow of this creek is bi-directional and it is further divided into several other creeks resulting in differences in the current of water. Substratum of the entire creek system is broadly diverse; though it is mainly composed of silt, some areas are entirely sandy while others are mixture of sand, silt and remains of dead leaves in different proportions. Nkoro is on latitude 4°33'0"N and longitude 7°28'0". The Creek which is a distributary of the Andoni River (Abowei, 2010) has for long been the means of sustenance to local fishermen through the fishery resources gotten from it that serve a primary and major protein source to indigenes, residents and neighbouring communities (Alagoa, 2005). Hence, economic activities in the fishery sector thrive in these areas as they support artisanal fisheries to local fishermen. This activity provides major sources of dietary protein and means of livelihood to indigenous fishermen. The has also served as a recreational centre for sports like swimming and boat regatta as well as providing habitat for a variety of plants and animals that are beneficial to man.

Three stations were sampled for this study, viz: Station I, Station II and Station III.

Station I lies at 7.462195°E and 4.559048°N. It is located in what is known to indigenes as Olom-Nkoro. Shoreline vegetation is comprised mainly of *Nypa fruticans* and insignificant patches of dwarf red mangrove *Avicennia harisonii*. The substratum is composed of silt and considerable quantity of sand. Major activities include local transportation, artisanal fishing and, occasionally, swimming.

Station II is about 200 meters away from Station I and between both stations is a confluence (Alagoa, 2005). It is located at Kalakunoma, a traditional burial site and lies between 7.463729°E and 4.553552°N. Substratum is composed of a mixture of silt and remains of dead leaves. At the shorelines *Nypa fruticans* and considerable portions of *Avicennia harisonii* and *Avicennia racemosa* are found, while hinterland is a forest of land plants comprised of *Militia excelsa*, *Cocus nucifera*, *Elaeis guineensis* and other shrubs. Dredging activities in local and commercial forms operate around here.

Station III is located at about 150 meters downstream of Station II in what is known to indigenes as Amatari. Fishing, swimming and dredging activities go on here. Overhung public latrine and residential buildings were around this study site. Vegetation along the shoreline is young stages of *Nypa fruticans*.

Determination of Physico-chemical Parameters

The physico-chemistry of the Creek is determined using standard methods (APHA, 1998). Sediments were collected using Eckman's grab, preserved with 10% formalin and stained with Eosin stain before it was taken to the laboratory for sorting and identification in a well labeled 3-liter transparent bucket. Sorting was done in the laboratory by transferring manageable quantities of the sediment into a plastic tray. To facilitate the

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process, moderate amount of water is added. Sorted macrobenthos are identified using Day (1981), Pennak (1978) and Umar *et al.* (2013) keys of identification.

Data Analysis

Organisms identified are counted, recorded and calculated for diversity indices, percentage abundance and analysis of variance for statistical significance across stations.

Results and Discussion

The study identified a community of 315 individuals of macrobenthic fauna from 4 phyla, 5 Classes, 11 Families, 13 Genuses and 13 species. The Phylum Arthropoda has the highest species (5 species) representative all of which are crustaceans while Gastropoda made up of *Pachymelania aurita* (16.19%) and *Tympanotonus fuscatus* (15.87%) is the most abundant Class in terms of number of individuals (Table 1). Table 2 showed that the physico-chemical indices considered by this study are within acceptable limits for aquatic life. Hydrogen ion concentration represents the acidity or alkalinity of an aqueous solution. The result of this study is near neutrality. It ranges from 6.9 at Station I to 7.6 at Station III. Temperature narrowly ranged progressively from 26.2°C at Station I to 28.1 at Station III. Dissolved Oxygen ranged from 7.2 – 7.9. Highest number of individual organisms (134), species evenness (0.905) and Margalef's index (0.866) were recorded at Station II. Station I is least in individual number of organisms (73), Margalef's index (0.823) and species evenness (0.814) but highest in species richness (12). Outside of species richness (10) where Station III was least compared to other stations, other diversity indices revealed that Station III is an intermediary between Stations I and II in terms of diversity indices results (Table 3).

Table 1: Checklist and Distribution of Macrobenthic Fauna of the Nkoro Creek in Niger Delta Region of Nigeria

Phylum	Class	Family	Species	Station I	Station II	Station III	Total	Percentage abundance (%)
Annelida	Polychaeta	Capitellidae	<i>Capitella capitata</i>	5	22	21	48	15.24
Arthropoda	Crustacea	Nereidae	<i>Nereis</i> sp.	4	3	5	12	3.81
		Alpheidae	<i>Alpheus pontederiae</i>	13	17	10	40	12.70
		Grapsidae	<i>Pachygrapsus</i> sp.	1	9	13	23	7.30
			<i>Sesarma elegans</i>	2	31	0	33	10.48
		Palaemonidae	<i>Palaemonetes africanus</i>	5	17	9	31	9.84
		Portunidae	<i>Callinectes amnicola</i>	2	6	1	9	2.86
Chordata	Actinopterygii	Gobiidae	<i>Yongeichthys thomasi</i>	1	0	3	4	1.27
			<i>Porogobius schlegelii</i>	1	5	0	6	1.90
		Ophichthidae	<i>Myrophis plumbeus</i>	3	0	2	5	1.59
Mollusca	Bivalvia	Arcidae	<i>Senila senilis</i>	0	3	0	3	0.95
	Gastropoda	Thiaridae	<i>Pachymelania aurita</i>	21	12	18	51	16.19

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		Potamididae	<i>Tympanotonus</i>	15	9	26	50	15.87
			<i>fuscatus</i>					
4	5	11	13	73	134	108	315	100

p>0.05

Key: % = percent

Table 2: Physico-chemistry of Nkoro Creek in Niger Delta Region of Nigeria.

Parameter	Station I	Station II	Station III	DPR, 2002	FMEEnv, 2002
Temperature (°C)	26.2	27.5	28.1	30	20-33
pH	6.9	6.8	7.6	6.5-8.5	8.5
Salinity ‰	10.2	10.7	9.5	250	Na
BOD (mg/l)	3.1	4.5	4.6	1.0	4.0
DO (mg/l)	7.2	7.9	7.6	5	6.8

p>0.05

Key: °C = degree Celsius; pH = Hydrogen ion concentration; ‰ = parts per thousand; BOD = Biochemical oxygen demand; DO = Dissolved oxygen; mg/l = milligram per liter; DPR = Department of Petroleum Resources; FMEEnv = Federal Ministry of Environment: na = not available

Table 3: Diversity Indices of Macrobenthic Fauna of Nkoro Creek in Niger Delta Region of Nigeria

Diversity Index	Station I	Station II	Station III	Total
Shannon-Wiener Index	2.022	2.17	2.001	2.258
Simpson's Index	0.173	0.134	0.157	0.12
Margalef's Index	0.823	0.866	0.843	0.88
Species Evenness	0.814	0.905	0.869	0.881
Species Richness	12	11	10	13

p>0.05

The macrobenthic fauna from Nkoro River (4 phyla, 5 Classes, 11 Families, 13 Genuses and 13 species) was not unusual compared with similar results of macro-invertebrates of the Niger Delta. George *et al.* (2010) reported a sum of 13,234 individuals of macrobenthos belonging to nineteen species across 6 sampling stations in the stretch of Okpoka River in a period of 12 months. Bassey *et al.* (2020) reported 39 subtidal macroinvertebrates in the Lagos Lagoon across 9 sampling stations between May and December 2018; Ibezute *et al.* (2016) isolated 803 individuals of macrobenthos from Ekpoba River in the Lower Niger Delta; and Moslen and Ameki (2018) identified 120 individuals of macrobenthic fauna belonging to three Insecta (58%), Oligochaeta (28%) and Crustacea (14%) from Isiokpo stream in Niger Delta between December 2016 and May 2017.

The Phylum Arthropoda has the highest species (5 species) representative all of which are crustaceans while Gastropoda made up of *Pachymelania aurita* (16.19%) and *Tympanotonus fuscatus* (15.87%) is the most abundant Class in terms of number of individuals. This result is similar to the report of Anyanwu, *et al.*

(2019) at Ossah River, Umuahia, South-eastern Nigeria. However, Rahman *et al.* (2021) and Haque *et al.* (2021) reported Oligochaetes (83% and 35.03%) as the most dominant macrobenthic group in the Gomti River and Bakkhali River of Bangladesh, India, respectively.

Highest number of individual organisms (134), species evenness (0.905) and Margalef's index (0.866) were recorded at Station II. This inferred that organic metabolic activity thrives at this station and the substratum is comprised of a mixture of silt and decayed organic remains of plant and animals providing adequate environment for the growth and prevalence of macrobenthos. According to the Shannon-Wiener diversity index classification proposition of Shekhar *et al.* (2008), water bodies with values greater than 4 are clean and unpolluted; those ranging from 3 to 4 are slightly-polluted waters, whereas values for severely-polluted waters fall below 2. This classification categorized Nkoro Creek to a non-severely polluted water since this study recorded more than 2 on Shannon-Wiener index (Table 3) across the stations. However, physico-chemical parameters (Table 1) reported are within national limits (DPR, 2002; FMEnv, 2002). Station I is least in individual number of organisms (73), Margalef's index (0.823) and species evenness (0.814) but highest in species richness (12). Since there are more number of species but less individual, it is indicative that parameters for spatial distribution of individual organisms is not favourable for macrobenthic fauna. Jonah *et al.* (2020) reported water physico-chemistry and faunal habitat to be limiting factors for macrobenthic assemblages.

Variations in temperature, salinity, pH and dissolved oxygen at the estuaries are pronounced (Levin *et al.*, 2011) following the mixing of marine water to freshwater. Feeding patterns, growth rates and breeding periods of aquatic organisms are influenced by temperature. In the Nkoro Creek, temperature narrowly ranged progressively from 26.2°C at Station I to 28.1 at Station III. Sikoki and Zabbey (2006) also reported similar narrow temperature range between 26°C and 27.8°C in the Bonny estuaries. Studies have indicated that atmospheric temperature (Jonah *et al.*, 2020) and other natural conditions (Gebreyohannes *et al.*, 2015) affect changes in surface temperature of water bodies.

Hydrogen ion concentration represents the acidity or alkalinity of an aqueous solution. The result of this study is near neutrality. It ranges from 6.9 at Station I to 7.6 at Station III. However, these values are within international and local limits (DPR, 2002) for fishery resources. Komi and Sikoki (2013) had similar outcome of pH ranging from 5.34±0.11 in June to 6.92±0.04 in October from the Andoni mud flats; Ibrahim *et al.* (2020) reported a pH between 7.00±0.38 and 8.01±0.41 at Bosso Reservoir, Niger State of Nigeria; and Ajibajare *et al.* (2020) recorded a pH of 6.60±0.01 in November 2017 to 9.37±0.54 in March 2018. Lower pH values less than 5.5 have been reported (Tripole, 2008) to cause absence of macroinvertebrates in Grande River sub-basin, San Luis, Argentina.

Salinity is the sum of solid salt substances, contained in one liter of water. Organisms in the estuary are subject to salt stress and must rapidly adapt in order to cope (Woke and Aleleye-Wokoma, 2014). Salinity decreased from upstream (10.2ppt) to downstream (9.5ppt). Ansa *et al.* (2007) and Francis *et al.* (2007) reported salinity range of 8ppt to 21ppt and 12 ppt to 22 ppt respectively in the Andoni rivers systems. Variation in salinity is contributed by seasons (Ajao and Fagade, 2002; Hart and Zabbey, 2005), proximity to and flow from freshwater or marine water source (Komi and Sikoki, 2013), tidal flows (Komi and Sikoki, 2013) and land derived freshwater inputs (Haque *et al.*, 2021) associated with the rainy season. Aquatic organisms are spatially distributed according to salinity differences as some organisms are stenohaline while others are euryhaline.

Useable oxygen in water is in the dissolved form. Woke and Aleleye-Wokoma (2014) noted that the amount of dissolved oxygen (DO) in a water body is a key parameter in determining the extent of organic life in such water body. This study recorded high dissolved oxygen concentration with a close range of 7.2mg/l at Station I to 7.9mg/l at Station II, which does not agree with Abowei's (2010) report on another portion of the Nkoro Creek between Nkontoru and Job-ama which showed a wide range of dissolved oxygen from

9.6mg/l to 0.4mg/l between January 2008 to December 2008. Ajijola and Ugwumba (2019) also recorded narrow DO values of 4.7 to 6.7mg/l in the Upper Benue River in Nigeria. Perturbation (Jonah *et al.*, 2020), organic load (Ayobahan *et al.*, 2014) and clarity of the water (Kale, 2017) are responsible for the fluctuations in dissolved oxygen recorded during this study.

Biochemical oxygen demand, the amount of dissolved oxygen needed by biologically aerobic organisms in a water body to break down organic materials present at a certain temperature over a given time, has widely become used as indicator of organic quality of water (Clair *et al.*, 2003). This study recorded BOD values of 3.1 mg/l, 4.5 mg/l and 4.6 mg/l respectively at Stations I, II and III. Wokoma *et al.* (2020) in a study at Sobreiro River, Niger Delta, Nigeria identified a BOD range of 5.41 ± 0.27 to 12.12 ± 0.66 mg/l making the river to be severely polluted as a result petroleum related human introduction. Arimoro *et al.* (2008) observed BOD levels between 2.38 to 13.64mg/l. According to Ajibare (2014), BOD values are affected by algal productivities, solubility of oxygen at varying temperatures and load of organic wastes.

CONCLUSION

Assessment of macrobenthos along with the physical and chemical characteristics of Nkoro Creek revealed that the Creek support macro-benthic fauna and its physico-chemistry are within recommended limits for aquatic life. The Creek support aquatic life including fishery resources owing to its physico-chemistry that are within national and international limits. Human interference from commercial sand dredging, illegal petroleum refinery, increased motored-vehicle transportation and environmentally unfriendly fishing systems are possible threats to these veritable macroinvertebrates in the Creek.

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COMPARATIVE ANALYSIS OF SOME SURFACE AND GROUND WATER QUALITY PARAMETERS FOR AQUACULTURE WITHIN YOLA METROPOLIS

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ABSTRACT

Comparative analysis of some surface and groundwater physicochemical parameters was studied over three months. Water samples were taken from Lake Geriyo, River Benue, Well, and Borehole twice a week. The water quality parameters measured were temperature, pH, dissolved oxygen, transparency, electrical conductivity, total dissolved solids, biological oxygen demand (BOD), and free carbon-dioxide. The highest mean temperature was observed from well water ($30.83 \pm 1.63^\circ\text{C}$) while the lowest was from Upper River Benue ($27 \pm 2.11^\circ\text{C}$). The mean pH values were 6.92 ± 0.32 , 7.01 ± 0.41 , 6.04 ± 0.24 and 6.39 ± 0.15 for Lake Geriyo, Upper River Benue, well water and borehole respectively and there was no significant different in their pH values. The highest mean dissolved oxygen was observed in Upper Benue River ($6.27 \pm 1.79\text{mg/l}$) while Lake Geriyo, well water and borehole water had $4.23 \pm 1.32\text{mg/l}$, $3.8 \pm 1.08\text{mg/l}$ and $3.67 \pm 1.53\text{mg/l}$ respectively. The electrical conductivity was very high in borehole water with mean value of $668.33 \pm 2.11\text{ppm}$ while Lake Geriyo, Upper Benue River and well water had lower electrical conductivity values of $230.33 \pm 3.45\text{ppm}$, $71.5 \pm 1051\text{ppm}$ and $200 \pm 2.28\text{ppm}$ respectively. Also, the total dissolved solid was very high in borehole water ($307.5 \pm 2.64\text{ppm}$) compared to what was obtained in lake Geriyo ($107.5 \pm 2.23\text{ppm}$), Upper Benue River ($39.17 \pm 1.84\text{ppm}$) and well water ($83.12 \pm 1.68\text{ppm}$). The biochemical oxygen demand was higher in Upper Benue River ($4.32 \pm 0.38\text{mg/l}$) compared to that of Lake Geriyo ($2.71 \pm 0.54\text{mg/l}$), well water ($1.11 \pm 0.21\text{mg/l}$) and borehole water ($1.89 \pm 0.51\text{mg/l}$). However, all measured water quality parameters are within the acceptable ranges of international and national standards for domestic waters. Hence; the water can be classify as good, stable and healthy for aquaculture purposes.

KEYWORDS: Water quality parameters, Surface water, Groundwater, Yola metropolis, Borehole water

1.0 Introduction

Water is a vital element in all aspects of life and plays an extremely important role in the continuous existence of human beings and the ecosystem as a whole. Water is important for aquatic organisms including fish for their survival, growth, recreation, nutrition, and reproduction. Currently, water is considered an emergency resource due to the negative effects of climate change, rapid population growth, urbanization, inappropriate use, and unsustainable management in many countries all over the world (IPCC, 2007). In coastal regions, water resources are frequently affected by various complicated factors, such as population growth coupled with the process of urbanization, seawater intrusion, wastewater without proper treatment, overexploitation, and unsustainable management (Ridolfi, 2011). These factors can be taken as the main causes of environmental degradation and freshwater scarcity in the world's coastal areas.

Lake Geriyo and River Benue, as surface water are been used for so many purposes such as fishing, irrigation activities (farming), transportation, and even for domestic uses, especially for the communities along the watercourse. Communities also depend on well and borehole waters as a source of water for their daily activities such as domestic usage and fish farming (aquaculture). Naturally, water resources interact frequently together (Shaw, 2013), such that if one of them is polluted or

affected, it may be a threat to another. In order to use and manage water resources sustainably, it is necessary to consider not only surface water but also groundwater source as an important component of the water cycle. Therefore, understanding the physical and chemical characteristics of surface water and groundwater is fundamental in the development of sustainable water resources management and policies most especially for aquacultural purposes

MATERIALS AND METHODS

Study Areas

The surface waters which are Lake Geriyo and Upper Benue River lie between longitude 12°25`E and latitude 9°8`N and longitude 12°47`E and latitude 9°28`N respectively of Adamawa State. Lake Geriyo is a floodplain lake directly adjacent to the Upper Benue River. While the borehole and well waters serve as the groundwater and they are within the Yola metropolis of Adamawa State.

Sample Collection

A total of 10 boreholes and 10 well waters were randomly selected within the sample area. Water samples were collected from the groundwater source and the surface water source twice a week and in triplicate for a period of three months (January to March). Pre-cleaned and labeled glass bottles were used to collect water samples. Parameters such as temperature, conductivity, hydrogen ion concentration (pH), Dissolved Oxygen, Total Dissolved Solid, and transparency were determined in situ while free carbon dioxide and Biological oxygen demand (BOD) were determined in the laboratory following the standard procedure of APHA (1998). Samples were usually collected between 8.00A.M and 9.00A.M.

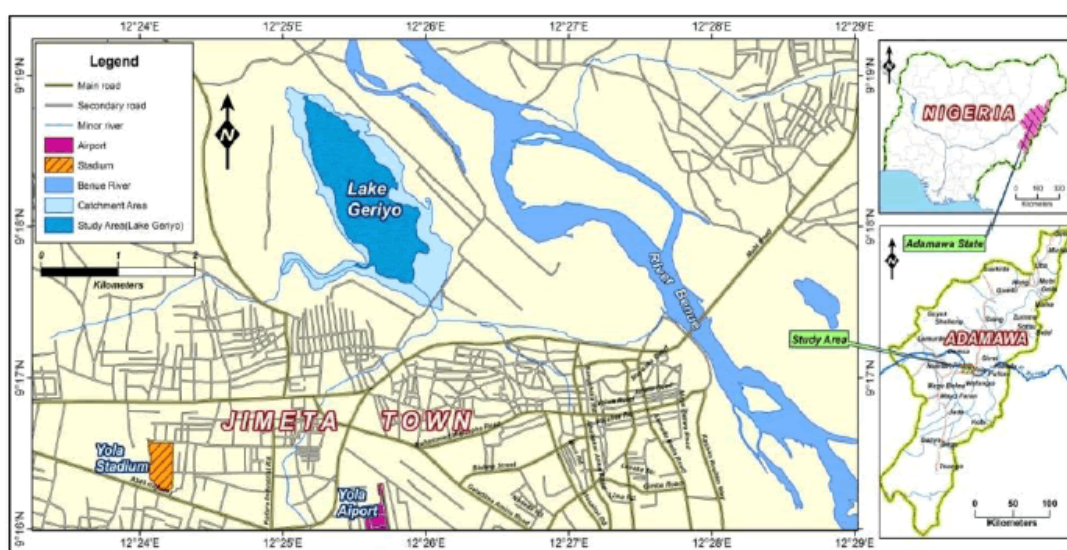


Figure 1: Map of lake Geriyo.

Results and Discussion

The results showed that well water had the highest mean temperature ($30.83 \pm 1.63^\circ\text{C}$) while the Upper River Benue had the lowest mean temperature ($27.12 \pm 2.11^\circ\text{C}$) as shown in Table 1. The Upper Benue River had the highest mean pH value of 7.01 ± 0.41 while Lake Geriyo, well water, and borehole water had 6.92 ± 0.32 , 6.04 ± 0.24 and 6.39 ± 0.15 respectively. The mean dissolved oxygen was found to be highest in Upper River Benue ($6.27 \pm 1.79\text{mg/l}$) while lower dissolved oxygen was found in well water ($3.8 \pm 1.08\text{mg/l}$) and borehole water ($.67 \pm 1.53\text{mg/l}$). The mean transparency was higher in Lake Geriyo ($33.33 \pm 4.12\text{cm}$) compared to that of Upper River Benue ($20.17 \pm 3.27\text{cm}$). No transparency was recorded for groundwater. The borehole water had the highest mean electrical conductivity ($668.33 \pm 2.11 \mu\text{m}$) and total dissolved solids ($307.5 \pm 2.64\text{ppm}$) while the Upper River Benue had the lowest mean electrical conductivity ($71.5 \pm 1051 \mu\text{m}$) and total dissolved solids ($39.17 \pm 1.84\text{ppm}$). The highest mean biochemical oxygen demands was recorded in Upper River Benue ($4.32 \pm 0.38\text{mg/l}$) while

the well water and borehole had lower mean biochemical oxygen demand of $1.11 \pm 0.21 \text{ mg/l}$ and $1.89 \pm 0.51 \text{ mg/l}$ respectively. The mean ammonia level in Lake Geriyo, Upper River Benue, well water, and borehole water were $0.004 \pm 0.01 \text{ mg/l}$, $0.003 \pm 0.01 \text{ mg/l}$, $0.006 \pm 0.02 \text{ mg/l}$ and $0.002 \pm 0.01 \text{ mg/l}$ respectively.

Several variations were observed in the physico-chemical parameters of the studied surface and ground waters. These variations may be associated with the mode of water usage and other environmental factors such as rainfall (Ayoade *et al.*, 2006). The temperature of the studied samples were relatively average because collection of samples were done at the peak of harmattan (January and February) and at the peak of hot weather (March). Similar mean temperature of 22°C to 28°C has been documented by Adedeji *et al* (2019) from Lake Ribadu, Adamawa State. Moreover, water temperature values have been reported to change in response to changes in air temperature (Anago *et al* 2013). However, the parameter falls within the optimum range for fish production in the tropics (Bhatnagar and Pooja, 2013). The transparency from the study ($33.33 \pm 4.12 \text{ cm}$ for Lake Geriyo and $20.17 \pm 3.27 \text{ cm}$ for Upper Benue River) are lower to the reports of Ani *et al.* (2016) who reported 49cm from Ebonyi River and that of Adedeji *et al.* (2019) who reported 43.40cm from Lake Ribadu Adamawa State. The observed variations may be due to differences in sampling duration as Ani *et al* (2016) and Adedeji *et al* (2019) sampled for twelve months while sampling was done for only three months in this present study. However, the transparency values still fall within the recommended values of 30-45 by WHO

The dissolve oxygen of aquatic system has shown negative correlation with temperature that is, as the temperature increases the dissolve oxygen decreases and vice versa. The dissolved oxygen in the surface waters is higher than that of the ground waters though still fall within the recommended value of FEPA and NAFDAC but lower to the recommended value of WHO. Other factors responsible for changes in the dissolved oxygen include depth, wind and the amount of biological activities that occurs in the system such as degradation (Bature *et al.*, 2017).

The average values recorded for pH in both the surface and ground waters is optimum for fish productivity and this agreed with the report of Ani *et al.* (2016) and Agbaire (2015) and also within the national and international standards (SON, FEPA; WHO). This shows a balance between photosynthesis and respiration in both studied waters. The mean electrical conductivity observed in this work is within the permissible limits of set standards (SON and FEPA) for domestic use and aquaculture. The total load of salts in water is directly related to its conductivity which in-turn is dependent on the ionic concentration and water temperature (Deline; 1992). Solomon *et al.* (2013) reported that high value of conductivity is an indication of water pollution and this is another justification that the sampled waters were not polluted. However, Sikoki and Veen, (2004) have reported that fishes differ in their ability to maintain osmotic pressure, therefore the optimum conductivity for fish production differ from one species to another

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Table 1: Mean values of physico-chemical parameters of surface and ground waters in Yola metropolis of Adamawa State

	Surface water		Ground water		International and National standards		
Parameters	Lake Geriyo	Upper River Benue	Well	Borehole	SON	FEPA	WHO
Temperature (°C)	29.67±1.57	27.12±2.11	30.83±1.63 ^a	28.83±1.73		26	40
pH	6.92±0.32 ^a	7.01±0.41 ^a	6.04±0.24 ^a	6.39±0.15 ^a	6.5 - 8.5	6.0 – 9.0	6.8
Dissolved Oxygen (mg/l)	4.23±1.32 ^b	6.27±1.79 ^a	3.8±1.08 ^b	3.67±1.53 ^b	> 4	> 4	> 6
Transparency (cm)	33.33±4.12	20.17±3.27					30 - 45
Electrical Conductivity (μm)	230.33±3.45 ^b	71.5±1051 ^c	200±2.28 ^b	668.33±2.11 ^a	1000	700	
Total dissolved solids (ppm)	107.5±2.23 ^b	39.17±1.84 ^d	83.12±1.68 ^c	307.5±2.64 ^a	500	500	1000
Biochemical Oxygen Demand (BOD) (mg/l)	2.71±0.54 ^b	4.32±0.38 ^a	1.11±0.21 ^c	1.89±0.51 ^c		-	
Ammonia (mg/L)	0.004±0.01 ^a	0.003±0.01 ^a	0.006±0.02 ^a	0.002±0.01 ^a	>0.005	≥ 1.0	
Free carbondioxide (mg/l)	15.5±1.02 ^b	13.0±1.89 ^c	22.0±1.46 ^a	18.17±1.71 ^{ab}	10-22.5	10	

Mean of Data with different superscript on the same row are significantly different (p<0.05)

The total dissolved solids observed in this present study is higher than the reports of Oyem et al. (2014) and Ani *et al* (2016) who both reported lower TDS from Groundwater in Boji-BojiAgbor/Owa Area of Delta State and selected Rivers in Ebonyi State respectively. The TDS of both the surface and ground waters in this present study are very far below the SON, FEPA and WHO recommended guideline value of 500 - 1000 mg/l. Water containing TDS of less than 1000 mg/l could be regarded as fresh water and good enough for both drinking, domestic and irrigational purposes as this would not affect the osmotic pressure of soil solution according to Shahidullah *et al.* (2000). However, extremely low concentration of TDS may be unacceptable because of its flat unexciting taste (WHO, 1996). Biological oxygen demand (BOD) observed in this study is similar to the report of Odoemelam *et al.* (2013) from cross river at Afikpo north local Government area of Ebonyi state, Nigeria. Though, this present study contradict the work of Kdu *et al* (2015) who reported a very high BOD from Tsaeda agam river in mekelle city, Tigray, Ethiopia. The BOD is the amount of oxygen required by micro-organisms that are present in the water to break down decomposable organic matters into simpler substances. The greater the decomposable matter present, the greater the biological.

5.0 Conclusion

In conclusion, a critical look at the physico-chemical parameters of both the surface and ground water falls within the stipulated and accepted ranges of national (NAFDAC, FEPA) and international bodies. Hence, the water can be classify as good, stable and healthy for aquaculture purposes. However, there must be a constant monitoring of the physico-chemical parameters of both the surface and ground water in order to ensure that they are in good state all time for aquaculture and domestic usages.

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**INSECURITY,
GENDER ISSUES,
CLIMATE CHANGE
AND
FISHERIES
GOVERNANCE**

ENHANCING FISHERIES INNOVATION IN NIGERIA: A REVIEW

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ABSTRACT

The need to increase fish production to provide the required source of protein for the teeming population in Nigeria has led to diverse development programme in the fisheries sub-sector of agriculture. The objective of this paper is to carryout a desk review of measures towards enhancing fisheries innovation, highlight functions of government in fisheries innovation and examine fisheries innovation system. The paper highlights that fisheries innovation is critically important for meeting the challenges that confront the human race including the need to improve competitiveness, sustainability and parity in fisheries sector. This ranges from improved fish seeds to current intensive management solutions, information/ communication technology for fish farmers in the fields, to making foods wholesome along the fish value chain. The study also noted that government plays a fundamental role in fisheries innovation in supplying the economic, social and institutional condition that foster innovation. It further posits that fisheries innovation system is interactive, holistic flows of knowledge among different stakeholders. The study concludes that fisheries innovation is highly valuable for increasing fish yields and subsequently, reducing poverty. Therefore, the study recommended that government at different levels should improve support for fisheries knowledge and information system for sustained role of fisheries innovation.

KEYWORDS: Fisheries, Innovation and Nigeria

INTRODUCTION

In Nigeria, the fisheries subsector of Agriculture is important to the Nigerian economy for contributing about 5.40% of the nation's Gross Domestic Product (GDP) (8,9). It also plays a significant role for national development through its contribution to employment, wealth creation, food/nutrition security and socio-economic development of riparian communities (Nwabeze *et al.*, 2009).

The present global challenges are bringing numerous pressures to bear on fisheries and other sub sector of agriculture such as population growth, the impact of climate change, greenhouse emission in agriculture, fast development of the emerging economy and increasing flux associated with water, land, and energy shortages. This circumstance heightens the critical role of fisheries innovation to make fish farming more lucrative, competitive and sustainable. Generally, fisheries innovation is a process by which something new or improved (whether technology or otherwise) is implemented in fisheries sub sector of agriculture with the purpose of creating positive change that will provide a way to meet needs, take on challenges or seize opportunities. It is socially proper and provides profit for the stakeholders' concerned. Therefore, fisheries innovation serves as a major driver for economic intensification. In view of the foregoing, this paper attempt to highlight practical measures towards enhancing fisheries innovation in Nigeria.

Objective of the study

The broad objective of the study is to examine the role of fisheries innovation in Nigeria. Specifically, the study;

- i. Examine measures towards enhancing fisheries innovation,
- ii. Highlight functions of government in fisheries innovation and
- iii. Examine fisheries innovation system.

Measures Towards Enhancing Fisheries Innovation

There is broad consensus that fisheries innovation is critically important for meeting the challenges that confront the human race including the need to improve competitiveness, sustainability and parity in fisheries sector. Fisheries also need to produce more fish for a growing population, using a limited amount of farmland, while at the same time reducing its green house emissions to avoid worsening climate change. This suggests that fisheries production needs to use knowledge more intensively, which means fish farmers must innovate.

Fisheries innovations hold great promise for tackling the growing demand for fish food and nutrition security in Nigeria (FAO, 2018). This ranges from improved fish seeds to current intensive management solutions, information/ communication technology for fish farmers in the fields, to making foods wholesome along the fish value chain. Fisheries and food system of the future can be more productive, more sustainable, more efficient and more interconnected. Fisheries innovation can make the world (Nigeria inclusive) to meet the growing demand for fish food as the population increases by:

- Improving the livelihoods of fishers/fish farm families by producing more and higher quality fish for a growing population: Closing the current gap in fisheries productivity in Nigeria (Tiamiyu *et al.*, 2015) will require a significant increase in fish yields. This will require modern practices such as stocking of fish seeds that can withstand environmental and biological stresses, fish fortification, mobile technology and mechanization among others. he
- Enhancing fish food nutrition security and safety to improve the health and well-being of people in Nigeria and around the world: Fisheries innovation is making it possible to improve the health and well-being of millions of people worldwide (Nigeria inclusive). A critical component of global fish food security will be ensuring not only the production of more protein, but enhancing the nutritional content and health profile of the fish food consumed. Following the increasingly migration from rural to urban areas and away from where food is grown, fortifying processed fish food will be particularly essential. In regions of severe under nutrition, such as Sub-Saharan Africa and South Asia, innovative public-private partnerships are being used to increase the nutritional content of food through the bio-fortification of indigenous products of animals and crops (WHO, 2012). Enriching nutritional value and wholesomeness of indigenous less value fish species through agricultural innovation will save and improve the lives of millions of children and adults.
- Contributing to fisheries sustainability through maximization of production resources: The trail of fisheries on our ecosystem is extensive consuming 70 percent of water for the irrigation of crops and other uses (World Water Development Report, 2014). Aside some negative environmental impacts, inland fish farming has the potential to contribute to the livelihood and food security of the riparian communities (Halwart *et al.*, 2003) and the focus is on aquaculture for overall development rather than aquaculture alone (Friend and Fuge-Smith, 2002). Improved water management satisfying both agriculture and aquatic resources recognize the multiple uses of inland water bodies and the complexity of livelihoods to promote their sustainability. Fisheries innovation is an important contributor to a more sustainable fisheries system that promotes constant improvement and reduced resource use. Research are targeted at developing high yielding fish seeds that are better adapted for high feed conversion rate, early maturity and disease resistant among others. Therefore, fisheries innovation is essential to enable farmers to produce more food with less resource.

Functions of Government in Fisheries Innovation

The government plays a fundamental role in fisheries innovation in supplying the economic, social and institutional condition that foster innovation. According to World Bank (2013), this is done through effective policy for;

- Providing agricultural resources with innovation (finances, services and knowledge) by building a suitable support system.
- Removing obstacle in regulatory frameworks including legal trade, governance and investment barriers.
- Strengthening the country's human resources through sound educational system that include all levels of schooling and occupational training, and thwart the brain drain.
- Promoting research and access to up-to date information by means of effective research policy that encourage greater investment in research and development, meeting the country's needs, seizing opportunities and creating effective linkages among all the creators and users of knowledge.

Fisheries Innovation System

The processes that make innovation easy do not emerge from nothing; it arises in a particular socio-economic perspective and is shaped by the presence of favorable situation in which it can flourish (IICA, 2013). The concept of fisheries innovation systems is wide range of sectors including research, extension, and other functions that promote or implement innovation. The system posits interactive, holistic flows of knowledge among different groups (Figure 1). The agricultural innovation process comes about largely within innovation systems made up of organisations, private and public stakeholders organized in different ways and possessing the technical, commercial and financial competencies and inputs required for innovation. It also includes the rules and mechanisms by which these different stakeholders interact and relate with one another in social, political, economic and institutional situations (World Bank, 2007). The performance of innovation system largely depends on the interaction between the diverse groups responsible for generating and disseminating knowledge and technology (OECD, 2002). The innovation system analysis produces significant contribution to a renewed holistic vision of fisheries and rural development, as it acknowledges that creating an enabling environment for fisheries actors to make innovative uses of knowledge through research and dissemination (FAO, 2018).

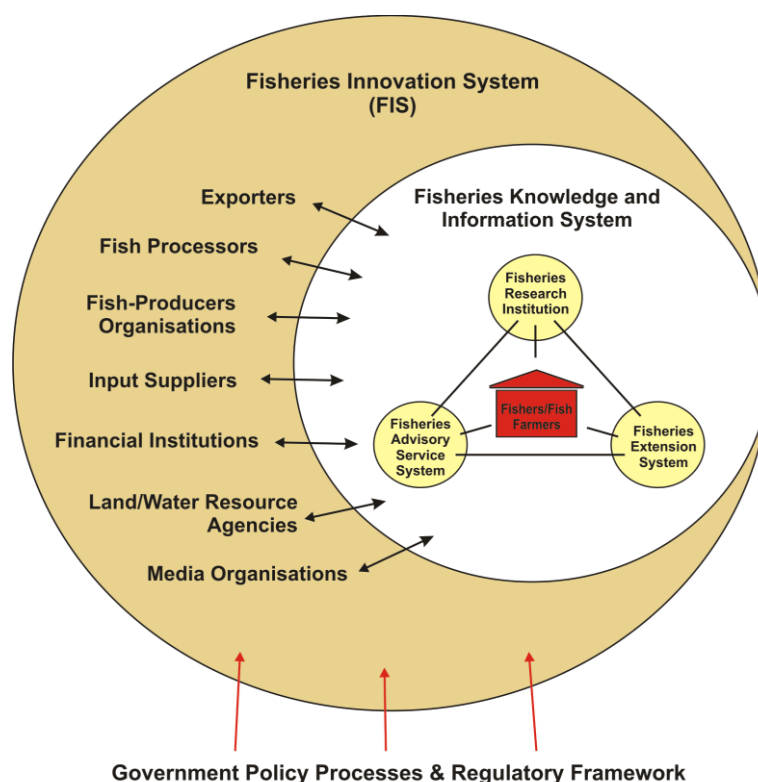


Figure 1: Fisheries Innovation System
Source: Modified from Birner *et al.* (2006) in FAO, (2018)

CONCLUSIONS AND RECOMMENDATION

Fisheries innovation is pivotal for economic growth and well-being of the nation. The role of fisheries innovation is significant and has considered being highly valuable for increasing fish yields and subsequently, reducing poverty. Therefore, the study recommended that government at different levels should improve support and coordination of fisheries knowledge and information system for sustained role of fisheries innovation.

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GENDER ANALYSIS OF TABLE SIZE AQUACULTURE PRODUCTION IN ADAMAWA STATE, NIGERIA

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ABSTRACT

The study examined gender analysis of table size aquaculture production in Adamawa State, Nigeria. Specifically, the study determined the profitability of table size aquaculture production disaggregated by gender and identified the factors influencing their outputs. Purposive and snowball sampling technique were used to select 108 male and 51 female table size fish farmers in the study area. Gross margin analysis and multiple regression model were used to analyze the data. The result revealed that average total revenue of ₦814.47 and ₦870.13 per kilogram were generated by male and female fish farmers, while a gross margin (₦547.55 and ₦583.91) and net income (₦387.36 and ₦423.24) of per kilogram respectively over a production cycle in the study area. The log-linear function of the multiple regression model gave the best fit with coefficient of multiple determination (R^2) indicating that about 72% and 58% of the variation in the output of male and female fish farmers were explained by the independent variables (fingerlings, quantity of feeds, pond size and quality of water) included in the model. The result further revealed that the number of fingerlings, quantity of feeds and amount of water influenced aquaculture production of both male and female fish farmers. The study therefore, recommends the establishment of aquaculture hatcheries and feed mills to reduce cost of production and increase output of both male and female farmers in the study area.

Keywords: aquaculture production, gender, cycle, gross margin

INTRODUCTION

Aquaculture production for nutritional and economic benefits as well as food security and income generation, has in the last few years witnessed an increased growth in Nigeria. It is an important sub-sector for the nation's economic development, at a time when government is seeking for ways to diversify the economy, from being purely oil based. It has potential of contributing to the food security of the nation, directly by producing fish for food and indirectly by generating employment for the teeming unemployed populace, save foreign exchange and generate foreign exchange through export of fish and fish products (Adewumi, 2015).

Aquaculture is the fastest growing food producing industry in the world. Over the past twenty years, global aquaculture production has quadrupled as a result of wild fisheries approaching their biological limits and the world demand for cultured fish continuing to increase (Ayinla, 2012). Aquaculture in Nigeria, which started in 1951 as a government-driven venture, has spread to all parts of the country majorly as a private sector-driven venture, encompassing all aquatic environments and using a range of aquatic species (Akinrotimiet *al.*, 2011). The aquaculture sector is driven by the private sector, with feed and seed provided by private business. 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 is the largest aquaculture producer in Sub-Saharan Africa and this importance is steadily increasing (FAO, 2017).

The National Wet Season Agricultural Performance Survey (APS) 2017 conducted by the National Agricultural Extension and Research Liaison Services (NAERLS), in collaboration with the Federal Ministry of Agriculture and Rural Development and state Ministries of Agriculture has shown a serious decrease in aquaculture and artisanal fish production in some states compared to the performance in 2016. For instance, Adamawa state produced 10,000 tonnes of fish in 2017, as against 20,000 tonnes produced in 2016; while fish production in Bauchi State and the Federal Capital Territory (FCT) recorded a decrease of 21.62 per

cent and 71 per cent in 2017 respectively. Kogi state produced 20,955 tonnes of fish in 2017, as against 271,315.11 tonnes produced in 2016, while Akwalbom state recorded a 46 per cent decrease, producing 96,590 tonnes of fish, as against 178,871 tonnes produced in 2016 (NAERLS, 2018). It noted that Nigeria's per capita fish consumption of 11kg was still lower than the global average of 21kg. Consequently, considerable attention is being given to aquaculture production as a means of increasing fish availability at affordable price.

In Nigeria, several studies are being carried out on aquaculture production but only few studies focused on the gender aspect especially in the study area. Gender analysis according to Tarida (1999) tries to understand the activities of men and women, patterns of men's and women's access to and control of resources and therefore enhances the understanding of social issues and the relation of production. This study therefore, examined aquaculture production dis-aggregated by gender in the study area with the following objectives:

- i. to determine the profitability of aquaculture production by gender and
- ii. to analyze the relationship between factors that influence aquaculture production in the study area by gender.

METHODOLOGY

The Study Area

The study was conducted in Adamawa State, Nigeria. It is one of the largest states in Nigeria with a land mass of 38,741km² lying roughly between latitudes 7° and 11° North and between longitudes 11° and 14° East of the Greenwich meridian (Adebayo, 2020). The State has an estimated population of 3.17 million people (NPC, 2006). With growth rate of (+2.94%/year), the State have an estimated population of 4,288,376 in 2018. It has an annual rainfall that ranges from 700mm to 1600mm in the extreme southern part of the State with a mean monthly temperature range of 26.7°C to 27.8°C. Adamawa State has a tropical wet and dry climate. The dry season lasts for a minimum of five months (November-March) while the wet season spans from April to October (Adebayo, 2020). It is bordered by the States of Borno to the Northwest, Gombe to the West and Taraba to the Southwest. It forms the eastern border with Cameroon (ASMOEP, 2014).

Sources of Data and Sampling Techniques

Primary data were collected with the use of a questionnaire for the study. Purposive and snowball sampling technique were used to select 159 fish farmers from some selected Local Government areas in the State (Yola North, Yola South, Girei, Fufure, Mayo belwa, Gombi, Mubi, Michika, Hong, Demsa, Lamurde, Guyuk, Shelleng and Numan local government areas of Adamawa State due to appreciable number of fish farmers in these local government areas.) out of which 108 were males and 51 were females. Snowball sampling technique or chain/referral sampling is a nonprobability sampling technique where an existing study subject recruit or refer a researcher to the next subject (respondents) from the same study population.

Analytical Techniques

Gross margin and inferential statistics were used to analyze the data. Multiple regression model was used to identify the factors influencing the output of the male and female fish farmers.

Gross margin (GM) = TR - TVC

NI = GM - TFC

Where: TR = Total Revenue;
TFC = Total fixed cost (₦);
TVC = Total variable Cost (₦);
GM = Gross Margin and
NI = Net income.

Multiple regression

The general statement of the multiple regression model is given as: $Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, U_i)$

Where: Y = Quantity of fish produced (kg)
 X_1 = Number of fingerlings (number),

- X₂ = Quantity of feed (Kg),
- X₃ = Labour (man hour),
- X₄ = Quantity of water used (litters),
- X₅ = Size of fish pond (meters square m²),
- X₆ = Experience (years)
- X₇ = Educational level,
- X₈ = Age (years),
- U_i = Error term.

The lead equation of the regression model is: $\ln Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8$

RESULTS AND DISCUSSION

Cost and Returns of Fish Production per Kilogram by Gender

Gross margin and net farm income analysis were used to determine the profitability of fish production for male and female fish farmers in the study area. Estimates of cost and returns analysis were made from fish farming using average cost (Fixed and Variable) and yield data generated by each of the sampled fish farmers per kilogram in a production cycle (6 months). The result in Table 1 revealed that male fish farmers incurred an average variable cost of ₦266.92 in a production cycle while the female fish farmers on the other hand incurred an average variable cost of production of ₦286.22 per kilogram. The average fixed cost of ₦160.17 and ₦161.00 per kilogram were incurred by male and female fish farmers respectively in the study area. The result also showed that the total cost of production of ₦427.10 and ₦446.88 per kilogram were incurred over a production cycle by male and female fish farmers respectively.

The result further revealed that an average total revenue of ₦814.47 and ₦870.13 were generated by the male and female fish farmers with a gross margin and a net income of ₦547.54 and ₦583.90 and ₦387.36 and ₦423.24 per kilogram generated by male and female respondents respectively over a production cycle. This therefore, revealed that fish farming was a profitable venture for both male and female fish farmers in the study area. The result corroborated the findings of Adebayo *et al.* (2016) who also reported that fish farming was profitable endeavor. However, the study indicates that the female fish farmers are making more profit per Kg than their male counterparts. This suggests that women fish farmers are likely to be more prudent in resource management and better record keepers than their male counterparts.

Table 1: Cost and Returns of Fish Production per Kilogram by Gender

Variables	Value (₦/kg)	
	Male	Female
Revenue	814.4741	870.1291
Variable cost	266.9279	286.2211
Fixed cost	160.1797	161.0063
Total cost	427.1076	446.8874
Gross margin	547.5462	583.9081
Net income	387.3665	423.2417

Source: Field Survey, 2018

Relationship between Fish Output and the Factors that Influence Fish Production for both Male and Female

The multiple regression model was used to analyze the relationship between fish output and the factors of fish production for both male and female in the study area. Four functional forms were tried and based on the economic, statistical and econometric criteria, log-linear function evolved as the lead equation.

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The results in Table 2 and Table 3 showed three explanatory variables, i.e. the number of fingerlings, quantity of feeds and quantity of water, were significant at 1%, 5%, and 1% for male and female fish farmers respectively. Furthermore, the coefficient of multiple determinations (R^2) of 0.72 for males and 0.58 for females implied that about 72% and 58% of the variation in the quantity of fish harvested by the farmers was explained by the independent variables included in the model. In addition, the F – statistics value of 31.96 and 7.32 for males and females respectively were significant at 1%, indicating model fit. This result is consistent with the finding of Oluwasola and Ige (2015) who in a study “Factors Determining the Profitability of Catfish Production in Ibadan, Oyo State, Nigeria” reported that the amount of labour used, quantity of feeds and farming experience influenced fish farming. It equally suggests the need for fish farmers to use more of these inputs in recommended quantities and quality as well as regular water checks to increase their outputs.

Table 2: Multiple Regression Result of Fish Production by Males

Variable	Parameters	Coefficient	Std. Error	t-Statistic
Constant	C	3.188746	0.102926	30.98107
No of Fingerlings	β_1	0.000112	1.12E-05	9.996797***
Quantity of feeds	β_2	-0.001081	0.000467	-2.316912**
Labour	β_3	-0.000288	0.000358	-0.803285
Quantity of water	β_4	-1.42E-07	1.17E-06	-0.120661
Pond size	β_5	0.000952	0.000285	3.333839***
Experience	β_6	-0.007324	0.006932	-1.056610
Educational level	β_7	-0.031917	0.019357	-1.648890
Age	β_8	-0.001780	0.002109	-0.844121

***, **, Represents Values that are Significant at 1% and 5% Levels Respectively

R-squared 0.720935
 Adjusted R-squared 0.698384
 F-statistic 31.96946***

Table 3: Multiple Regression Result of Fish Production by Females (Exponential)

Variable	Parameters	Coefficient	Std. Error	t-Statistic
Constant	C	2.751610	0.214230	12.84419
Number of Fingerlings	β_1	2.70E-05	9.83E-06	2.742941***
Quantity of feeds	β_2	0.002009	0.000967	2.077288**
Labour	β_3	0.001079	0.000770	1.401518
Quantity of water	β_4	4.51E-06	1.86E-06	2.428568***
Pond size	β_5	0.000879	0.000867	1.013572
Experience	β_6	-0.006425	0.014937	-0.430130
Educational level	β_7	0.030976	0.033600	0.921890
Age	β_8	-0.002484	0.003937	-0.630960

***, **, Represents Values that are Significant at 1% and 5% Levels Respectively

$R^2 = 0.582563$; Adjusted $R^2 = 0.503052$; $F = 7.326758$ ***

CONCLUSION AND RECOMMENDATIONS

The study concluded that aquaculture production for both males and females was profitable in the study area; however, female fish farmers were making more profit per Kg than their male counterparts. This suggests that female fish farmers are more prudent in resource management than male fish farmers. The study further concluded that number of fingerlings, quantity of feeds, pond size, and amount of water influenced aquaculture production. The study therefore, recommends that hatcheries and feed mills be

established in the study area to reduce the cost of production and increase output. In addition, policies that will ensure availability of inputs to further encourage both males and females should be put in place by the relevant stakeholders.

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THE EFFECTS OF INSURGENCY ON FRESH FISH MARKETERS IN MAIDUGURI METROPOLITAN COUNCIL, BORNO STATE, NIGERIA

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ABSTRACT

The study was conducted to examine the economic effects of insurgency on fresh fish marketing in Maiduguri Metropolitan Council (MMC). A total of one hundred (100) copies of questionnaire were distributed in two fresh fish markets (Monday market and Gamboru fish market). Data were analyzed using descriptive statistics and gross margin analysis. The result obtained reveals that the majority of the respondents were males (77.5%), falling within the age group of 40-49 years (52.5%) and they are married (75%). The study also indicates that most of the respondents had household size between 1-5 persons with their highest educational level as secondary (48%) and their major occupation were farming (80%) with

highest marketing experience of 11-15 years (45%). the market chain is producer – wholesaler – retailer – consumer. The major constraint to the fresh fish marketing in the study area was consumers' income (37%). In conclusion, the insurgency has an economic effect on the study area and it's recommended that the government should encourage large scale production of fish, improve the security situation and enhance the consumer's income by regular payment of salary of workers.

Key words: Fresh fish, Marketers, Maiduguri Metropolitan Council and Insurgency

INTRODUCTION

Fish constitutes a very important component of diet for many people and often provide much needed nutrient for a healthy living (Adeleke and Afolabi, 2012; Olaoye, 2010). However, fish is an extremely perishable food commodity than cattle, sheep and poultry, it gets spoilt very quickly after capture (Adeosun and Adebukola, 2012; Omoregie *et al.*, 2001).

A market is defined as an area over which buyers and sellers negotiate the exchange of a well-defined commodity (Olayinka and Aminu, 2006). Marketing includes all the processes (assemblage of goods, storage, transportation, processing, grading and financing) involved from the point of production of a commodity to the point of final consumption (Crammer *et al.*, 2001). These processes ensure that the right product is available at the right place, at the right price and at the right time to fully satisfy the consumers (Okoh *et al.*, 2008).

Market structure is defined as those characteristics of a market which strategically influence the nature of competition and pricing within the market (Olukosi *et al.*, 2005). Market structure is influenced by a number of factors which include among others; the number and relative size of buyers and sellers, the degree of product differentiation, the ease of entry and exit of sellers into and out of the market and the status of knowledge about cost, price and the conditions among the participants in market (Mejeha and Ifenkwe, 2007). On the other hand, market performance is the appraisal of the extent to which the interactions of buyers and sellers in a market stimulate result that is consistent with social purposes (Olukosi *et al.*, 2005). Olukosi *et al.* (2005) defined marketing channel as the pathway through which a commodity passes from its raw form to the finished form. It is the sequence of intermediaries and market through which goods find their way from producers to the consumers. Marketing channels according to Olukosi and Isitor (1990) can be classified into centralized and decentralized channels. A centralized channel has agents who serve as middleman between producers and consumers while decentralized channel is a kind of channel where both consumers and agents can buy directly from the producers (Madugu and Edward, 2011).

Other socio-economic problems such as transportation and distance from the point of sale to the final consumers have affected the quality and cost of fish products (Gittenger, 1984).

However, the raging boko haram insurgency in the north east has hit the region's fishing industry, causing shortages and driving up prices (National Emergency Management Agency, 2015). Fish sellers have suffered so much financial setback as a result of the Boko haram insurgency.

Therefore, the aims of this study are to determine the socio economics characteristics of fresh fish marketers; examine cost and return of fresh fish marketing before and during insurgency; determine marketing chain and margin of fresh fish marketing and identify marketing constraints to fresh fish sellers.

The Study Area

The study was conducted in Maiduguri Metropolitan Council (MMC) of Borno State, Nigeria. Maiduguri is the capital of Borno state. It lies between latitudes 11° 48 N to 11° 50 and longitudes 13°06 E to 13°14 E at an altitude of 345M above the sea level. It has a total of approximated land area of 69,436 square kilometres with a population projected to be 786, 485 people in 2012 based on 3.2 annual growth rate.

The economy of Maiduguri is largely based on services and trade with a small share of manufacturing (Mele and Chien, 2007).

Sampling procedure

Two (2) markets were purposively selected based on their fresh fish market potential within the Maiduguri Metropolitan Council (MMC). These are the areas where fish marketers are easily accessible in the local government. These include Gamboru and Monday markets. Random sampling procedure was used to select fifty (50) fish sellers from each market making a total of one hundred (100) respondents for the study.

Data collection

Both primary and secondary sources of data were used. The primary data were collected through the one hundred (100) questionnaires administered to the respondents in the study area while the secondary data were collected through textbooks, journals, newspapers, bulletins, pamphlets, magazines, thesis, extension guides etc.

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Data Analysis

The data collected were analyzed using descriptive statistics such as frequency distribution and percentage.

Results and Discussion

Results of the social economic characteristics of respondents are as shown in Table 1 below. The findings of the study showed that respondents' ages ranged between 20-50 years with an average age of 35 years. The results further showed that most of the respondents in the study area were between the ages of 30-39 (52.5%) and 20-29 (25.0%). Only 10.0% of the respondents fell between the ages of 40-49. Very few respondents (7.5%) were less than 20 years of age. Even though the results show that the majority of respondents were in their 30's, they were still very active to be involved in Fresh fish marketing.

The results in Table 1 further showed that majority (75.0%) of the respondents is married and 20.0% are single. Furthermore, 5.0% are separated. This finding is further supported by the report of Omotayo (2011), where most of the marketers were found to be married. It was suggested that this could positively affect the productivity and wellbeing of the business as other family members, such as the wife and children, could assist with the marketing aspect by storing excess fish left over with ice block, thereby serving as source of labour.

The findings revealed that most of the respondents (47.5%) have mean household size 5. Household size has proven to be a great contributor to productivity. Although Ajani and Ashagidigh (2008) argued that household's contribution to productivity could be said to be based on a personal view of interest as an increase in household size increases expenditure and this decreases marketer's annual income.

Table 1: Socioeconomic Characteristics of the Respondents

Items	Frequency	Percentage (%)
Gender		
Male	77.5	77.5
Female	22.5	22.5
Age		
20-29	7.5	7.5
30-39	30	30
40-49	52.5	52.5
50-59	10.0	10.0
Marital status		
Married	75.0	75.0
Single	20.0	20.0
Divorce	5.0	5.0
Household size		
1-5	45	45
6-10	31	31
11-15	14	14
Educational level		
Primary	30	30.0
Secondary	48	48
Tertiary	15	15.0
Non formal	8	8
Main Occupation		
Farmer	80	80.0
Trader	13	13
Civil servant	7	7
Marketing experience (in years)		
1—5	8	8.0
6—10	20	20.0
11—15	45	45.0
>15	28	28.0

Source: Field Survey, 2021

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Moreover, high proportion of the respondents (47.5%) had secondary education. This is supported by the finding of Ogunkoya (2014) (56-57), which revealed that the majority of the respondents in her study had the standard form of education. This finding is also in line with a statement made by the Land Bank of South Africa (2000), that marketers who have passed standard five are regarded as literate enough to make decisions about marketing, production and the requirement of agriculture.

Table 2 reveals that the major problem hindering the fresh fish marketing in the study area were consumers income which constituted (37%) of the respondents, followed by seasonal fluctuation of fresh fish supply (28%), high cost of the product, high tax (11%), exploitative middlemen (4%) while transportation constituted (2%). This shows that the major constraints of the fresh fish marketing which is seasonal fluctuation of fresh fish supply, may be due to the drying off of river after rainy season. This work agrees with the findings of Clucas and Ward (1996) who reported that fish supply has been one of the problems militating against adequate fish consumption and fish marketing in most markets in Nigeria, hence reduces intake of animal protein.

Table 2: Factors hindering fresh fish marketing

Factors	Frequency	Percentage (%)
High tax	11	11
Seasonal fluctuation of fresh fish supply	28	28
Consumers income	37	37
High cost of the product	18	18
Transportation	2	2
Exploitative middlemen	4	4

Source: Field Survey, 2021

Results of profitability margins are as shown in Tables 3 and 4 below.

Based on the profitability analysis, the marketing of fresh fish were found to be profitable with profit margin of N5, 690 and N6, 780 per 20kg basket of fish during and before insurgency respectively. This indicates that insurgency has affected the profit margin of fish marketing from N6, 780 to N5, 690.

Table 3: Profitability analysis of fresh fish marketing before insurgency

Expenditure	Amount (₦)	Revenue	Amount (₦)
Cost of 1basket of fresh fish(20kg) Loading and off	11,000	Sales of fish	18,000
Tax	50		
-loading/basket	40		
1 packet of black polythene	110		
Water	20		
Total variable cost	11,220	Total Revenue (TR)	18,000

Source: Field Survey, 2021

Profitability = TR - TVC

Where:

TR = Total Revenue

TVC = Total variable cost

Profitability = 18,000-11,220

= N6, 780

Table 4: Profitability analysis of fresh fish marketing during insurgency

Expenditure	Amount (₦)	Revenue	Amount (₦)
Cost of 1basket of fresh fish(20kg)	18,000	Sales of fish	24,000
Tax	50		
Loading and off-loading/basket	60		
1 packet of black leather	160		
Water	40		
Total variable cost	18,310	Total Revenue (TR)	24,000

Source: Field Survey, 2021

Profitability = TR - TVC

Where:

TR = Total Revenue

TVC = Total variable cost

Profitability = 24,000-18,310

= N5, 690

CONCLUSION

The findings of this study reveal that insurgency has an economic effect on the marketing of fresh fish in the study area. This is evident in the fact that, the profit margin of the fresh fish marketing was observed to be higher in the study area before the insurgency. The marketing of the fish were hindered by consumers' income and its marketing chain flowed from producer – wholesaler – retailer – consumers.

RECOMMENDATIONS

Based on the results obtained from this study, the following recommendations were made:

- i. Government should encourage production of fish in the study area by training the youths and giving them production inputs to enhance fresh fish supply in the study area;
- ii. Government should grant tax relieve on scarce food commodities such as fish in the study area to maximize the profit of the fresh fish marketers.
- iii. Government should make additional effort to improve the security situation in the study area to encourage further production and availability of fresh fish.
- iv. Government should make road network available in the hinterland where fish production takes place to ease the transportation of fish and reduce marketing cost.

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FISH PRODUCTIVITY AND CLIMATE VARIABILITY NEXUS IN NIGERIA: THE NEED FOR POLICY REFORM

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ABSTRACT

This study is a review of literature highlighting climate change with emphasis on its effect on fishery ecosystem in Nigeria. Particular consideration was given to freshwater fish habitat given its prevalence in Nigeria and its sensitivity to factors that influence climate change. The review as well identified possible causes of climate change and the effect on fishery enterprise. The study showed that fish production practices varied due to changes in ecological zones emphasizing the effect of climate on different climatic zones. Major factors of climate change that could influence fish production were temperature changes associated with climate change, the effect of climate change and water cycles, weather events, and eutrophication. There was a complex relationship between climate change, fishery production and anthropogenic activities influencing global warming. Policies that influence fish productivity by reducing the effect of climate change were encouraged.

Keywords: Adaptation, Aquaculture, Climate change, fisheries, mitigation

1. INTRODUCTION

The fishery sector constitutes an important component of food for mankind. The sector is an important determinant in the development matrix of Nigeria. It provides employment and contributes about 40% of animal protein recommended for the daily needs of humans (Alabi and Erie, 2010). Fish is a protein source without any cultural or religious bias. This may explain why fish production is important as food and revenue-generating enterprise. The enterprise generates income in processing, preservation, and the marketing chain. Despite the effort to produce, process, and market fish and its products, demand had never meet-up with the supply. With a population of about 216,729,557, Nigeria depends heavily on fish for food (Worldometer, 2022). This justifies the increasing demand for fish as population increases. FAO (2014) observed that increasing populations depend on fish as source of proteins from the artisanal sector. Increasing fish demand in Nigeria may be the result of increasing population and income. Nigerian fish valued at 13.3 kg/capita/year is small when compared with the world's average of 20.3 kg/capita/year (Bradley *et al.*, 2020). The value is lower for the vulnerable portion of the population. Fish improve the food security position of the population.

A general challenge for increased fish productivity is availability of feed resources. Fishers depend more on fish landed from the wild. This increases the challenge of availability given that captured fish is passing through a challenge exacerbated by climate change. This change affect productivity emphasizing the need for the identification of a sustainable fish production resource. While the fish is important as a food source, the effect of climate change on the sector may not be appreciated (Barange and Perry, 2010). The objective of this paper is to review literature on the effect of climate change on fish productivity. To achieve this, the paper seeks to identify the possible causes of climate change and its effect on the Nigerian fishery enterprise. The study will establish the link between fish productivity and changes associated with climate change. Finally, policies will be proposed to attenuate the effect of climate change on the fishing enterprise if implemented. The remaining part of the paper is split into; climate change and aquaculture production nexus, climate change extremes in Nigeria, policy on fish production and climate change mitigation approach. The last section concludes the study with appropriate conclusion and recommendations.

2 Climate change and aquaculture production nexus

Climate change is associated with changes in biological and physical systems that depend on the climate for observed results. Climatic change over time influenced fisheries production and aquatic life. Bindoff *et al.* (2007) observed that global warming from 50–100 years leads to thermal expansion resulting to the expansion of water and melting glaciers, declined pH, and a change in circulation pattern of water and air. This will affect the water bodies in the country, both inland rivers, floodplains, and lakes, and the temperature change will affect the aquatic life in response to the different intensities of climate change. Changes resulting from climate change had not been identified in Nigeria, temperature change, pH and the volume of water bodies will lead to fluctuation in stock sizes.

3. Climate change extremes in Nigeria

Drought is considered as an important factor contributing to increased climate variability thereby limiting high fish productivity. Recurrent drought in Nigeria affects aquatic ecosystem, driving fish farmers to go for alternative fishing method even with the attendant costs. High temperature is a weather factor that influences aquaculture production through its effect on the aquaculture environment. The ways by which climate change affect fisheries and aquaculture include extreme events like floods, droughts, and storms. In temperate regions, it may result to melting of ice and glaciers. Changing temperature and precipitation may affect river flows. This may be through flooding leading to erosion or drying up of water bodies with increased temperature. Another approach may be water acidification may affect aquatic life and aquatic food chain. With increasing sea temperature, mortality for aquatic life may increase. Climate change complexity may affect aquaculture through increased fish production input price and technological innovations. Some of the major effect of climate change in fish production and aquaculture are the following;

a. Effect of climate variability on water temperature

With increasing global temperature change, the temperature of water bodies tends to change. Water temperature is an important variable when considering environmental factors that influence fish performance. Temperature is the most influential factor of all environmental stressors that affect freshwater fisheries. Fishes from freshwater habitats are vulnerable to the effects of changing water temperature. Given that fishes depend on their aquatic environment in regulating their body heat mechanism, the biological, chemical, and physical mechanisms of the fish tend to alter. Increased temperature may lead to stunted growth, impaired metabolism, distorted maturation process, exposure to mortality, the tendency for migration and changing distributional patterns. Literature on the effect of changing climate on freshwater fish productivity in the country is scarce. A Study by Ndebele-Murisa *et al.* (2014) show that increasing temperatures in lake waters Africa accelerate the rate of decline in phytoplankton. Phytoplankton and zooplankton constitute an important component of fisheries' food chain.

b. Thermal Divisions of aquatic environments

The surface temperature of water relates closely to atmospheric temperature. With the increase in atmospheric temperature resulting from climate change, surface water temperature also increases. The density structure of water bodies changes with changing temperature. Layers of warm, less-dense warm water forms the first layer at the top followed by less dense and colder layers referred to as thermal stratification. A stratified water body tends to be relatively stagnant with vertical profiles of water with different temperatures, pH, and dissolved gasses. With stratification, the introduction of nutrients to the aquaculture habitat is reduced. Ndebele-Murisa *et al.* (2014) in his study identified this phenomenon in stratified lakes in Malawi, Niger, and Chad. Stratification tends to impose restrictions and limit habitable areas for aquatic life, imposing a balance between favourable temperature and dissolved oxygen needs. Given that aquatic organisms can adjust within limited temperature limits, their performance tends to be restricted within a specific thermal niche.

c. Effect of climate change on water cycle

The water cycle describes the circulation of water in the atmosphere as well as below the surface. According to the United States Geological Survey (USGS) (2016), water cycle affects human activities and changing climate. Changes associated with the water cycle are influenced mainly by climate change. Climate change is influenced by rainfall patterns, runoff patterns and water vapour resulting from increased temperature. Literature shows a decline in the effect of climate change that affects water availability for animals and plants. The effect in aquaculture is the volume of water availability with a significant effect on the productivity of aquatic life consequent upon the volume and physio-chemical properties. Runoff after rainfall increases nutrients to aquatic environments and increases the volume of water, therefore, providing a suitable environment for aquatic life. This shows that with years of abundant rainfall, nutrients are extensively released into flooded valleys leading to increased aquatic populations.

d. Climate change and eutrophication

Water bodies may be increasingly enriched with nutrients and minerals leading to increased production of phytoplankton. The process is referred to as eutrophication. Water may flow into enclosed areas resulting to changes in the ecosystem. Process leading to eutrophication is subject to natural and slow processes. The process as of recently had been increasing at an accelerated rate. Many reasons may explain the change in the rate of eutrophication. Following the work of Chislock *et al.* (2013) the increased use of fertilizers for agricultural purposes, the disposal of industrial waste followed with the disposal of sewage to water habitats remains some of the major factors influencing the eutrophication process. This is corroborated by Nazari-Sharabian *et al.* (2018) who opined that climate change influences eutrophication with the interactions of meteorological factors with nutrient availability. Rising temperatures as a result of climate change have increased bacterial activity leading to the depletion of oxygen from aquatic habitats. For example, the growth of blue-green algae in aquatic habitats increases water temperature (Nazari-Sharabian

et al., 2018). Another negative effect of increasing aquatic habitat is the production of toxic metabolites called cyanotoxins.

e. Climate change and weather events

Climate change is reflected by the intensity of drought and floods. The effect of climate change is reflected in the intensity, period of effect of climate change, and frequency of weather events that may affect the volume of water in aquatic environments, loss of stock, destruction of fishing equipment, and stock loss (WorldFish Center, 2017). A study on the impacts of flooding on fishing in Nigeria showed a reduction in fish catch, destruction of fishing gears, loss of family income, and disruption in education (Chukwu, 2014). Drought adds to human pressure on scarce freshwater resources for agriculture and manufacturing purposes that may reduce habitat productivity during dry periods thereby affecting aquatic life. Water deficit that results from climate change or drought may cause a volume decrease in aquatic habitat leading to increased salinity in the freshwater ecosystem. Studies show that lake Chad is under continuous effects of drought from 22000 Km² to 300 Km² from the 1960s to the 1980s (Gao *et al.*, 2011).

e. Climate change adaptations in aquatic ecosystem

Adaptations to climate change are variations to natural systems resulting from the effects of climate that reduce harms and benefits to aquatic life from the results of the climate change. According to literature, fish adjust to environmental change by changing its biology and phenology (Gao *et al.*, 2011). This is possible given that ectoderms in aquatic environments regulate their body temperature while their rate of metabolism, physiological process, and growth rate change with climate change. A study by James and Washington (2013) opined that some fish species migrate to suitable habitats with increasing changing temperatures. Fishing communities adjust to changing fish resources through planning at individual, community, national or regional levels. There are approaches to climate change which include; the diversification of livelihoods, identification, and use of new fish species, changing and upgrading the different fishing gears and migration are methods that could be adopted in the short-run. Mgana *et al.* (2019) adopted the technology of adopting home-made light-emitting diodes (LEDs) to improve fish catches on Lake Tanganyika. Some of these improved strategies are detrimental to the habitat and might result in the extinction of some aquaculture species, thereby affecting the food security status of fish-producing communities.

4. Policy on fish production and climate change mitigation approach

It is important to highlight the importance of protecting and conserving aquatic resources. Though the government controls the fishery enterprise, co-management with fish-dependent communities is necessary. Co-management strategy in fish production leads to improved fish production and improves information sharing thereby, offering the opportunity for scientific information and experience in management. Approaches for mitigation and adaptation to climate change can be initiated with increase in atmospheric and Green-house Gases (GHGs). A study by Halls (2009) shows that even in a small-scale fishery in Nigeria, the ability to mitigate the effect of climate change is limited. The Intergovernmental Panel on Climate Change (IPCC (2007) suggests that the conservation of wood during fish smoking by employing a small quantity of wood to smoke a large feed quantity of fish will contribute to mitigating climate change. Another approach is the use of gas smoking kilns or solar dryers to reduce increased carbon gas emissions leading to reducing in the effect of climate change.

The rate at which the fishery and aquaculture sectors adapt to climate change depending on the influence of the farmers, the participation of the farmers, their financial status, their location and their level of financial capacity and scale of aquaculture taking place. Success for a particular adaptation process depends on appropriate policy formulation, species diversification, improved cultural practices and cover-tree planting. Other adaptation approaches like timing of particular fishing approach and migration of fish species should be facilitated. Other approaches could be research finding to select appropriate species that

could withstand salinity and increasing temperature. Tree establishment has a combination of economical, ecological and social influence on the aquatic life as well as inhabitants of the particular area. Well established trees do not only provide shelter for fishery production but also creates a conducive environment for fish nursery and other aquatic organisms. Tree root network contributes to aquatic biodiversity and provide water filtration services to aquatic life. Well established tree cover habitat in riverine areas provide income by the collection of shellfishes, sea-shells and aquatic life in those areas. Tree establishment in aquatic environments provide homes for aquatic organisms, different types of insects, reptiles, birds, and tree primates. The extent of climate change can be determined by the hydrological cycle with activities around water bodies like siltation and pollution as a result of dam construction.

5. CONCLUSION AND RECOMMENDATION

This review paper revealed that climate change is an environmental challenge affecting the fishery sector in Nigeria. The review identified factors influencing the fishery enterprise under changing climatic conditions. The factors are; temperature of aquatic ecosystem, the stratification of aquatic environments, the change in water cycle, eutrophication, weather events, aquatic ecosystem, climate change mitigation and policy approaches. Government influence on the fishery sector may ease access to input and adaptation of fishes leading to yield improvement. Maximization of fish productivity is the aim of adapting to climate change. Therefore, improved aquaculture practices could serve as an intervention for adaptation. Climate change adaptation strategies could be improved if fish farmers are trained on adaptable strategies including agroforestry to improve vegetation and microclimate. There is need for further research on efficient adaptation strategies to improve farmers' resilience to climate change.

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GENDER DIFFERENTIAL IN THE USE OF FISHING GEARS IN ARTISANAL FISHING ACTIVITIES IN SOME SELECTED FISHING COMMUNITIES IN BADAGRY, LAGOS STATE.

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ABSTRACT

The study investigated the relationship between gender differentials in the use of fishing gears in coastal artisanal fishing in Badagry area of Lagos State. Specifically, the study sought to understand whether gender is associated with the use of fishing gears in artisanal fishing. The study adopted a non-experimental research design and cross-sectional quantitative survey. The study selected fishing coastal communities in the Badagry area of Lagos State, and the study population comprised adult males and females. Using a

combination of probability and non-probability sampling techniques, a sample size of 300 was selected. Structured questionnaire was used to elicit information from respondents. It was found that gender was significantly associated with use of fishing gears in artisanal fishing as men were far more likely to involve in these activities than women. It was argued that women are being set aside in the fishing industry despite the fact that the activity has been attributed to women since perennial times in the literature. Policies that will enhance significant inclusion of women in the use of fishing gears were suggested.

Keywords: Fishing gears, Gender, Coastal, Artisanal, Badagry.

INTRODUCTION

The Nigeria fishery sub sector is of three major types, namely, the small scale or artisanal fisheries, the large scale or commercial fisheries and aquaculture or fish farming. Artisanal fishermen are defined as independent fish harvesters whose livelihood are based on fishing on a full time basis, using low capital, low technology fishing techniques, and employing family or community/hired labour, often on a sharing basis, for harvesting in riverine habitats (USAID Oceans, 2018). However in Nigeria for example, the coastal artisanal fishing makes use of traditional dug-out canoes, roughing from three to eighteen meters (3-18m) in length. While the gears used include case nets, hand lines, baskets, traps, long lines, set gill nets and breach purse seines. In practices however, the scope of artisanal fishing varies between men and women in the Badagry coastal communities.

In integrating gender value chain in artisanal fishing activities there is need to build on the evidence showcasing the link between greater gender equity and poverty reduction due to outcomes in improved productivity and innovation, household income, nutrition, child health and education. This agenda moves beyond past frameworks that considered gender as an individual characteristic of women and the potential 'gender gaps' between them. Worldwide, women in fishing communities have been observed to participate actively in fisheries and also play a part in the maintenance of their families (Nwabeze et al, 2013). In many parts of the world, women have engaged actively in fish business. In the European countries for instance, women control 39% of the fish industry, making a huge amount of money for themselves and their families (Aguilar, 2002). The crucial engagement of women in natural resources-based occupation such as fisheries in the rural communities has long been accepted but not recognized and not valued as men contribution (Obetta et al, 2007).

However, fish production is customarily considered as masculine venture, women role in fish related activities is though supportive, is imperative and indispensable (Cliffe et al, 2011). In other words, their roles is repeatedly being ignored and neglected in fisheries production as a result of primordial systems of social setting which undermines the contribution of women in family and society is prevalent in the rural areas of many developing countries like Nigeria. According to (Tamela 2004), the non-recognition of women contribution in fishing process is enhanced by uneven allocation of resources. Therefore, lack of access and control over productive process is one of the major factors limiting women participation in economic activities such as coastal fishery practices (Acharva 2003). Women in rural areas participate actively in the traditional fisheries sub-sector of the economy. They are either fully involved or play a complementary role for men in provision for their families. There is therefore the need to promote and to encourage women folk in this sector, so as to boost supply of fish food and improve the economic welfare of their families (IFAD. 2008 Ekpo 2013).

The study therefore, investigated gender differentials in coastal fishing activities in some selected coastal communities of Badagry Local Government of Lagos State in order to evaluate the relationship between gender and the use of fishing gears in artisanal fishing as an important tool for boosting gender participation and improving their livelihood.

Materials and Methods

Proceedings of the 37th Annual Conference of FISON

The study was conducted between March 2017 and July 2018. Ten villages were selected purposively based on fisheries resources and women involvement in fishing activities in the ten selected communities in the Badagry area of Lagos state. A non-experimental research design which consists of cross-sectional survey method was adopted to identify the relationship between gender and use of fishing gears in artisanal fishing in Badagry.

RESULTS AND DISCUSSION

Table 1: Distribution of Respondents by Socio-demographic characteristics

Sex	Frequency	Percent (%)
Male	142	48.6
Female	150	51.4
Total	292	100.0
Age	Frequency	Percent (%)
20 and below	43	14.7
21-30	144	49.3
31-40	29	9.9
41-50	37	12.7
51-60	30	10.3
61-70	4	1.4
71- Above	5	1.7
Total	292	100.0
Marital Status	Frequency	Percent (%)
Single	79	33.2
Married	179	61.4
Divorced	8	2.7
Separated	8	2.7
Total	292	100.0
Level of Education	Frequency	Percent (%)
None	44	15.2
Primary	117	40.5
Secondary	101	34.9
Tertiary	27	9.4
Total	289	100.0

Source: Field Survey, 2018.

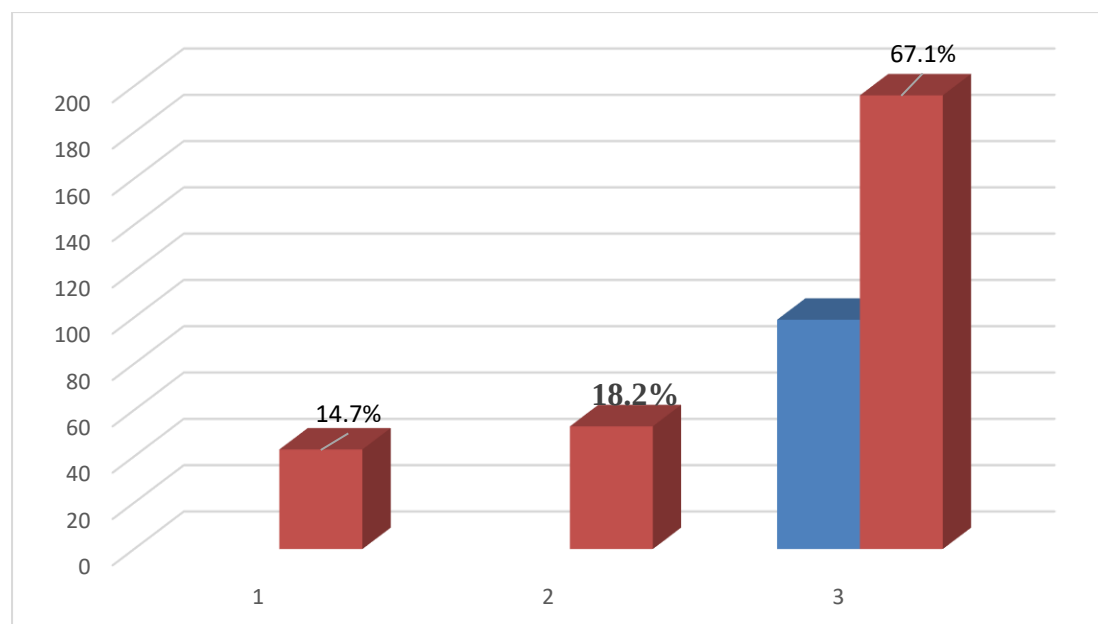
Table 1 above shows the distribution of respondents by socio-demographic data. The table indicates that majority of the respondents in this study (51.4%) were female. Similarly, majority of the respondents (49.3%) were between 21 and 30 years of age. Likewise, the table shows that majority of the respondents (61.4%) were married. Furthermore, the table indicates that majority (40.5%) of the respondents had primary school education

Table 2: Distribution by Frequency of Fishing Gears

FISHING EQUIPMENT USED	RESPONSE		TOTAL	PERCENT	
	YES	NO		YES	NO
Outboard engine	56	1	57	11.5	1.2
Plank canoe	53	4	57	10.9	4.9
Cast net	53	4	57	10.9	4.9
Set net	56	1	57	11.5	1.2
Drag net	46	11	57	9.4	13.4
Paddle	46	11	57	9.4	13.4
Pole	42	15	57	8.6	18.3
Hooks and line	46	11	57	9.4	13.4
Traps	48	9	57	9.8	11.0
Head lamp	42	15	57	8.6	18.3
TOTAL	488	82	570	100.0	100.0

The table above shows the percentage distribution of respondents by fishing equipment used. The table indicates that 56 representing 11.5% of the respondents use Outboard engine; 53 representing 10.9% of the respondents use Plank canoe; another 53 representing 10.9% of the respondents use Cast net; 56 representing 11.5% of the respondents use Set net; 46 representing 9.4% of the respondents use drag net; another 46 representing 9.4% of the respondent use Paddle; 42 representing 8.6% of the respondents use Pole; 46 representing 9.4% of the respondents use Hooks and line; 48 representing 9.8% of the respondents use Traps and 42 representing 8.6% of the respondents use Head lamps. The table further reveals that the fishing equipment used by a substantial number of the respondents are Outboard engine and Set net.

Chart 1: Distribution of Respondents by whether they currently use Fishing Gear



The chart shows the distribution of respondents by whether they currently use fishing gear. The data shows that 45 (14.7%) of the respondents are not currently using a fish gear, while 53 (18.2%) of the respondents are currently using fishing gear. The table shows that majority of the respondents are currently using fishing gear.

INFERENCE ANALYSIS

Test of Hypotheses

Ho: There is no association between gender and the use of fishing gears in artisanal fishing in Badagry

Table 3: Cross-tabulation between gender and the use of fishing gears in artisanal fishing

Gender	Have you ever used a fishing gear?		Total
	No	Yes	
Male	68 48.6%	72 51.4%	140 100.0%
Female	56 90.3%	6 9.7%	62 100.0%
Total	124 61.4%	78 38.6%	202 100.0%
X²: 31.600; df: 1; P-value: 0.000			

Source: Field Survey, 2018.

The table shows that a little above half (51.4%) of males use fishing gears, while less than one-tenth of females use the equipment. The chi-square value of 31.600 and p-value of 0.000 indicates that males are significantly more likely to use fishing gears than females.

DISCUSSION

This study has highlighted several important issues concerning gender variation in the use fishing gears in coastal artisanal fishing activities in Badagry, Lagos State. The study pointed that gender is a significant predictor of use of fishing gears in artisanal fishing in Badagry. The analysis infers that males are significantly more likely to use fishing gears than females in Badagry because the predominant occupation of male in the selected fishing communities is fishing which involve the use of certain tools for fishing called “fishing gear”. This means that people that engage in coastal fishing activities invariably uses fishing gears to carry out their activities and from the hypothesis it was discovered that majority of people that use gears in coastal fishing activities were male.

The result of the study therefore reveals that gender is a significant predictor for the use of fishing gears in coastal artisanal fishing activities in Badagry. This implies that gender informs the types of fishing gears used for coastal artisanal fishing activities in Badagry. This is because the use of fishing gears by males and females has been socially constructed for ages; therefore it is passed from generation to generation. This finding is collaborated by the result of Akinyemi, (2000) ‘Socio-Cultural Determinant of the Use of Fishing Gears’: a study of five fishing communities. Which reviews that there is significant difference in the fishing gears use by males and females, in other words, males use fishing gears that are different from the ones use by females? This finding is further supported by Ogunbiyi (2013) who’s work on ‘Women Participation in Fishing’ reveals that women favour the use of lighter and more portable fishing gears than men.

CONCLUSION

In a nutshell, it is apparent that gender is a significant predictor of participation in coastal artisanal fishing activities in Badagry, Lagos State. The study was able to give vivid explanation of the general objective of the study. It has been able to illustrate that gender is a significant factor that influences the differential in the use of fishing gears in the areas of study

RECOMMENDATIONS

By going through the results obtained, in order to improve coastal artisanal fishing activities, where gender is a significant predictor in the use of fishing gears. Government through its agent (Ministry of Agriculture)

should provide fishing tools for fishers as this can help and as well encourage women to engage more in coastal fishing activities and invariably add or boost fish production in the country.

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EVALUATION OF FOOD INSECURITY STATUS OF FISH FARMERS IN OSUNSTATE

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ABSTRACT

Fish farmers in Nigeria face food insecurity despite their contribution to the national gross domestic output. This has been attributed to limited access to resource, market access and low prices for their outputs. This study sought to examine the food insecurity status of fish farmers in Osun State, Nigeria. The study used the descriptive correlational survey design and a sample of 150 fish farmers, using multistage sampling. The results of the study revealed that fish farmers experience some form of food insecurity and was found to have significant relationship with economic sustainability, challenges of fish farming, sex, age and reason for fish farming. For economic, social and environmental sustainability, sex and reason for fish farming were significant to influencing food insecurity as sex and economic sustainability influence sometimes food insecurity. Only age was a significant predictor of often food insecurity status. The study recommends sustainable production practices to improve food security status.

KEYWORDS: Evaluation, Food insecurity, Fish Farmers, Osun State

Introduction

The world food policy over the last few decades has been centered on increasing production capacity to meet the world population growth. The concept of food security in current time as expanded to look at the access, availability, utilization and stability. Added dimension of food security has been the physical and economic access of food that meets individual dietary needs. The two most renowned definition of food security has been the United Nations (1975) and FAO (1983). United Nations in 1975 under the world food summit defined “food security as the availability at all times of adequate supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices”. This definition was expanded by FAO in 1983 to include access of vulnerable groups to available food supplies as an expansion of balancing the demand and supply of food production to meet the need of people. Similarly, FAO (2002) improved on the definition to look at the dietary diversity and preference as a condition for food security. The revolving definition of food security has made a true definition for food security complex. However, in this study, food security is defined along the National Foods Security Program (NFSP) (2001) in Nigeria, which looked at food security “as the physical availability and ability of individuals to have or afford the food at a reasonable cost”. One of the sectors which has been considered to be of vital importance to achieving food security has been the aquaculture sector.

Aquaculture is the rearing of fish species in cultured environment. The shifting concept to the aquaculture sector in the last decade has been the ability of the sector to improve food availability and welfare of households through the provision of employment, nutrition and income (Love *et al.*, 2020). Also, fish farming has the potential of accelerating the drive to achieving the sustainable development goal one, and two on poverty reduction, and zero hunger. In Nigeria, fish farming is practiced mainly through the pond system (Adeleke *et al.*, 2020). However, areas with water bodies such as rivers and lake practice the cage system. The common fish species reared are the tilapia and catfish. The aquaculture sector in Nigeria is mainly dominated by small to medium scale enterprises with a few large-scale enterprises which practice polyculture in a semi-intensive system (Kaleem and Sabi, 2021).

Recent statistics shows that Nigeria total demand for fish as part of dietary needs stands at an estimated 3.6 million tonnes, while domestic production from the artisanal, aquaculture and industrial sector contribute 1.1 million tonnes (Omananyi, 2021). The deficit of 2.5 million has to be imported, that leaves the question of availability, accessibility and stability of these imported fish to meet the needs of vulnerable groups. This exacerbates the issue of food insecurity for households. According to Ogundari (2017), the food security issues in Nigeria is reflective in the National Living Standards Survey (NLSS) in 2004, which indicated that 90 percent of household incomes are spent on food as wage rate and food prices continues to have direct relationship. Similarly, report in 2007 by the National Bureau of Statistics, Nigeria added that poverty incidence is expected to hit 54.4 percent with already 74 percent of the population already below the poverty line. In the southwestern part of Nigeria of which Osun state form's part, 43 percent of the population are poor. Out of the number, 47 percent of them live in the rural areas where fish farming is predominated. Okunmadewa (2001) added that despite fish farmers producing close to 45 percent of Nigeria total fish output, fish farmers continue to be food insecure as farmers cannot meet the 65 g of protein and 2500kcal of energy. The major reason has been attributed to low incomes as against raising prices of food product on the market. This implies that fish farmers cannot meet their dietary requirement all year round. The problem is compounded by unemployment, limited access to resource and barriers to self-sufficiency, which intend worsen the food security needs of these farmers. This study seeks to examine the food security of fish farmers. This is further broken down into specific objectives as; examine the extent of food insecurity among fish farmers, examine the relationship between food insecurity and farmer characteristics and the factors influencing fish farmers food insecurity status.

Materials and Methods

Research Design: The study used the descriptive correlational survey design to ascertain the interplay between primary fish actor's characteristics and food security. The descriptive correlation survey was selected because it gives a snapshot of food security issues of fish farmers.

Study Area: The study area is Osun state. Osun state is located in the south-west of Nigeria with its capital, Osogbo. The state is known for its major contribution to aquaculture fish stock of the country. This is attributed to the location of the state which sits at the rainforest belt of the Western uplands, making it one of the adequate rain receiving state in Nigeria. Geographically, the state lies between longitude 4⁰ and 5⁰ E and latitude 7⁰ and 8⁰ N. It covers an estimated land size of 14,875 km square. The area is one of the few states in Nigeria where the government has embarked on massive fish farming promotion as part of the federal government goal to reduce poverty, generate employment and ensuring improved nutrition among local residence. The state is one of Nigeria's major producers of agriculture output.

Sample Procedure and Sample size: In selecting the sample size for the study, a multistage sampling was conducted with the first stage being the stratification of the state into three strata based on existing Agriculture Extension zonation made by the Extension department in the area. The zones were Iwo zone, Osogbo zone, and Ede zone. Stage two saw a simple random sampling used to select one community each from the zone due to the homogeneity of fish farmers in the zones. The last stage used simple random sampling to select 50 respondents from each community. This led to a total sample of 150 fish farmers used for the study.

Method of Data Collection: The data collected for the study was mainly primary data through the use of questionnaires. The instrument had questions based on the farmer characteristics, sustainability practices adopted and, food security questions. Food security was measured using the Household Food Insecurity Access Scale Indicator (HFIASI).

Measurement of variables and data analysis: In analysing the objectives of the study, the study used bar chart to represent the indicators of food insecurity. The second objective was analysed using correlation analyses. The correlation analyses was carried out to test the association between food insecurity, sustainability and farmer characteristics. The last objective was analysed using multivariate regression with the dependent variables being rare, sometimes and often food insecure. The independent variable were farmer characteristics, sustainability indicators.

Table 1: Descriptive Statistics of the respondents

Variables	Definition	Expected Direction	Mean $\pm$ SD
Non-fishing activities (nfishing)	1-Yes 0-No	+	
Economic sustainability (Ecostat)	Continuous scale	+	34.487 $\pm$ 7.810
Social sustainability (Socstat)	Continuous scale	+	11.081 $\pm$ 4.014
Environment sustainability (Envstat)	Continuous scale	+	10.592 $\pm$ 1.774
Fish farming challenges (Chall)	Continuous scale	+	6.014 $\pm$ 1.581
Sex	1-male 0-female	+/-	
Age	Continuous scale	+	3.228 $\pm$ 11.800
HHZ	Continuous scale	+	5.536 $\pm$ 1.687
Fish farming experience (Fexp)	Continuous scale	+	5.375 $\pm$ 3.807
Reason for fish farming (ReasonF)	1-income 0-others	-	

Results and Discussions

Extent of fish farmers' food insecurity: Figure 1 shows the extent of fish farmers' food insecurity. The figure shows that majority of fish farmers were rarely food insecure. This shows that fish farmers experience some level of insecurity. Similar study by Shava and Gunhidzirai (2017) in Zimbabwe shows that fish farmers were more likely to be sometimes food insecure, which contradict the findings of this study.

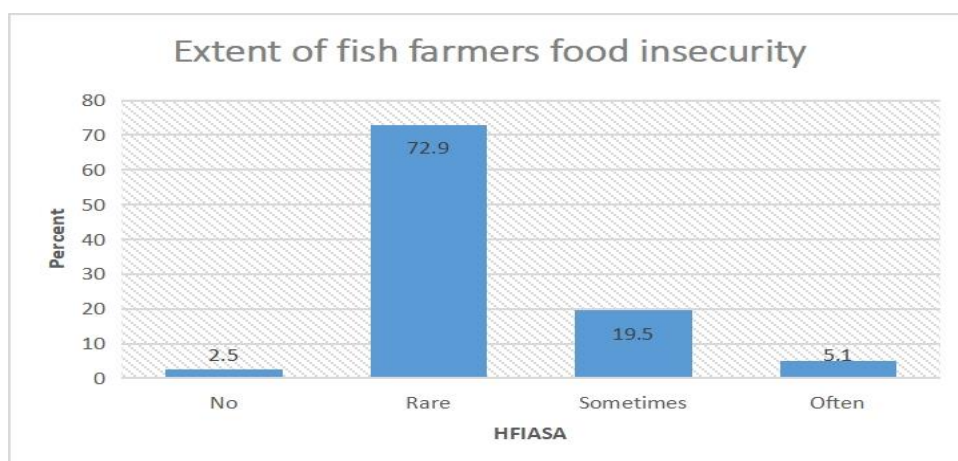


Figure 1: Extent of fish farmers food insecurity n- 150 Source: Field Survey (2019)

Relationship between food insecurity and farmer characteristics: Table 2 shows the relationship between food insecurity and farmer characteristics. The result shows that economic sustainability and food insecurity are negatively moderately significant as challenges to fish farming, sex, age and reason for fish farming having a direct relationship with food insecurity. Despite the positive significant relationship, sex, reason for fish farming and challenges to fish farming had low correlation as only age had moderate relationship. This shows that fish farmers practicing economic sustainability has the ability to improve their food insecurity status. Berry *et al.* (2015) also discovered that there was a negative significant association between economic sustainability and farmer food insecurity.

Table 2: Relationship between food insecurity and farmer characteristics

Independent Variables	Type of correlation	Correlation coefficient	*p-value	Strength of correlation
Non-fishing	Point biserial	-.119	.199	Low
Ecostat	Pearson	-.417*	.000	Moderate
Socstat	Point biserial	-.164	.077	Low
Envstat	Spearman	.099	.286	Negligible
Chall	Pearson	.257*	.005	Low
Sex	Point biserial	.298*	.001	Low
Age	Point biserial	.406*	.000	Moderate
HHZ	Spearman	.036	.723	Negligible
Fexp	Spearman	.017	.867	Negligible
ReasonF	Pearson	.205*	.029	Low

Source: Field Survey (2019) *p-value<.05

Factors that influence fish farmers' food insecurity: Table 3 shows the factors that influence the food insecurity status of fish farmers. The result shows that the independent variables explain the dependent variables (rarely, sometimes and often) by 84.1 percent, 34.1 percent and 22.5 percent. This shows that the independent variables are good measure of the dependent variables. This is further supported by the p-value <0.05 of significance. An in-depth look at Table 3 shows that sustainability (economic sustainability, social sustainability and environmental sustainability), sex and reason for fish farming were significant in influencing fish farmers' rare food insecurity. However, only economic sustainability and sex were significant to influencing fish farmers being sometimes food insecure. Only age was significant in influencing fish farmers being often food insecure.

Table 3: Factors that influence fish farmers' food insecurity

Variables	Rarely	Sometimes	Often

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	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
nfishing	0.0623	0.0551	-0.0198	0.0531	0.0065	0.0345
Ecostat	0.0301*	0.0061	-0.0102*	0.0059	-0.0042	0.0038
Socstat	0.0207*	0.0112	-0.0074	0.0108	-0.0021	0.0070
Envstat	-0.0487*	0.0287	0.0257	0.0277	0.0113	0.0180
Chall	0.0139	0.0256	0.0022	0.0247	-0.0259	0.0160
Sex	-0.2181*	0.1082	0.3432*	0.1044	-0.0493	0.0678
Age	-0.0041	0.0044	0.0040	0.0043	0.0050*	0.0028
HHZ	0.0155	0.0251	-0.0286	0.0242	0.0160	0.0157
Fexp	0.0199	0.0140	0.0004	0.0135	-0.0053	0.0087
ReasonF	-0.2124*	0.1041	-0.0257	0.1004	0.0577	0.0652
Equation	Obs.	Parms	RMSE	R ²	F	P-value
Rarely	150	10	0.354	0.841	41.665	0.000
Sometimes	150	10	0.341	0.344	4.136	0.001
Often	150	10	0.221	0.225	2.295	0.020

n= 150 *Sig.@ 10% Source: Field Survey (2019)

As fish farmers continue to practice economic sustainability, and social sustainability, the chance of their food insecurity being rare increases by 3.01 percent, and 2.07 percent. However, as fish farmers practice environment sustainability, the chances of their food insecurity worsening increases by 4.9 percent. Additionally, males were 21.8 percent more likely to have worse food insecure compare to females. Also fish farmers who do fish farming solely for income generation are 21.2 percent more likely to have worsen food insecure than farmers who mainly do fish farming for consumption and income generation. As fish farmers practice economic sustainability only, there is 1.02 percent chance of them having food insecurity worsen than sometimes while males have 34.2 percent chance of being sometimes food insecure. As age of fish farmers increase, there is 0.5 percent of being often food insecure because they spend more on social activities than on improving their food security. The findings of Akuffo and Quagraine (2019) which disagree with this study shows that household size of farmers play a significant role in influencing their food insecurity status.

Conclusion and Recommendations: The study concludes that fish farmers experience some form of food insecurity. The majority of fish farmers used for this study had moderate food insecurity. Food insecurity was found from the study to have significant relationship with economic sustainability, challenges of fish farming, sex, age and reason for fish farming. Also, economic, social and environmental sustainability, sex and reason for fish farming were significant to influencing rare food insecurity as sex and economic sustainability influences sometimes food insecurity. Only age influence fish farmers being often food insecurity. The study recommends that the ministry of agriculture through the department of fisheries and aquaculture should encourage fish farmers to practice sustainability to improve their food security status. Also, the ministry of agriculture through the department of fisheries and aquaculture should encourage fish farmers to rethink their marketing strategy to also consume some of the fish produced to improve their food security status.

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INVOLVEMENT OF WOMEN IN FISHERIES AND AQUACULTURE VALUE CHAIN IN NIGERIA: A REVIEW OF THEIR ROLE AND CHALLENGES

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ABSTRACT

Aquaculture is one of the fastest growing food producing sector in the world today and it is developing; expanding and intensifying globally. The resultant growth and intensification of aquaculture has increased the value chain actors and value addition is now vital in the processing, preservation and packaging of aquatic produce taking into consideration the consumers and the market preferences,. The vital role of women in aquaculture value chain, fish processing, value addition and decision making is unnoticed and need to be reviewed and taken into consideration when formulating policies in developmental plans. In view of the critical women play in the fisheries and Aquaculture value chain, there should be a deliberate effort on the part of Policy makers to mainstream women into the decision making organ of the Fisheries and Aquaculture sub-sector..Furthermore they should be given financial incentives that will enable them stand on their own and take ownership of small scale Fisheries and Aquaculture businesses where they dominate.

Keywords: Aquaculture, Fish, Value Chain, , Women roles, Involvement

INTRODUCTION

The term aquaculture is the culture; breeding and harvesting of fish, shellfish and other aquatic organisms like fin fishes (Clarias, Tilapia, and Mullet), Molluscs (periwinkles, cockles, clams and oysters), Crustaceans (crabs, prawns and shrimps), Amphibians (frogs) and aquatic plants in a confined environment (FAO, 2005). Aquaculture production in the world has grown by about 34.5% from the production level of 4.73 x 10⁸ million metric tonnes in 2006 to 6.36 x 10⁸ tonnes in 2011 and today it contributes 42.2% to total fish production worldwide (FAO,2014). The resultant growth in aquaculture have broadened the aquaculture

value chain and value addition of harvested produce is now a vital occupation done by women who are indispensable in fisheries and aquaculture because of the important role they play.

Aquaculture plays a crucial role in fisheries development and will continue to play a very big part in boosting global fish production in meeting the rising demand for fishery products. Nigeria has 14 million hectares of inland water surface out of which 1.7 million are available and suitable for aquaculture which shows the huge potentials of this industry if properly harnessed (FAO, 2006). Shimang (2005) reiterates this point further when he pointed that Nigeria has vast network of inland waters like rivers, floodplains, natural and man-made lakes totaling about 12.5 million hectares and capable of producing 512,000 metric tonnes of fish annually. Ekelemu (2011) and Oluwasola and Ajayi (2013) posited that potentials and the growing interest shown by government and the private sector, the gap between the demand of fish in Nigeria (1.3 million metric tonnes annually) and supply of fish from domestic production (about 0.45 metric tonnes annually) has continued to widen.

THE CONCEPT OF VALUE ADDITION AND VALUE CHAIN

Fish is a highly perishable commodity. Farmers often experience substantial post – harvest losses due poor handling and inability to promptly dispose of their harvest. Fish value addition and value chain as a concept in Fisheries and Aquaculture production is a veritable means of generating additional revenue, opening up the employment space while at the same time mitigating post-harvest losses, especially when harvest is much. Value chain in small-scale fisheries comprises the various activities prior to harvesting and harvesting proper, until getting to the final consumer. These activities may include but not restricted to construction of Fishing gears, harvesting, grading/sorting, washing/cleaning, processing, haulage and marketing. Josupeit (2016), further opined that value addition is any activity along the supply chain that increases the usability, culinary attribute or economic viability of a seafood item. He posited that value added products are usually perceived to be those that have undergone some measure of processing or addition of ingredients such as a coating or sauce, prepared, trimmed or in some way more convenient to the user. Value addition is the most talked about word in the food processing industry today particularly in export-oriented fish processing industry because of the increased realization of valuable foreign exchange which is gotten from this process. Value can be added to fish and fishery products in many ways according to the requirements of different markets and consumer's preferences. The essence of value addition apart from increasing shelf life of the produce also helps in shoring up revenue generation, because the value-added product, attracts higher price. Some ways of adding value to Fish products are Smoking, Sun-drying, Filleting, Grilling, production of fish balls, fish fingers, fish barbecue, fish oil and fish trash (Adedayo, 2016; Ekelemu *et al*; 2021; Idiku, 2022). The concept of value addition to aquaculture products presents reasonable opportunity for additional revenue generation, job creation. It is an effective post-harvest management not forgetting that value chains are vital for understanding how a product moves from the producer to the customer (FMARD, 2014). De Silva (2011) noted that a wide range of factors drive consumers demand for fish and fishery products and these factors should be taken into consideration when creating a new value-added or value-created product. These factors include taste, fashion, advertising and the expectations of consumers. Value chains are a key framework for understanding the producer to the customer and how a product moves from the producer to the customer. They are important tools for high-impact and sustainable aquaculture, improving and enhancing productivity, competitiveness, entrepreneurship, identifying new markets for exports, SMEs growth and improved understanding of the business relationship or environments. Value chain transforms low-skill, low-value products and services and contributes value-added share of these products to the global market trade. The major aspects of aquaculture value chain opportunities are fish production and fish marketing and distribution through a well-defined and diversified system. It should be noted that value chains comprise all the ancillary activities in between production and markets, such as input supplies and processing (Gorman and Webber/, 2014). Fish spoilage sets in soon after capture and this is a major problem especially in Nigeria where fisher folks, artisanal fishermen and fish farmers lack modern preservation and storage facilities on board canoes or in fishing communities. Even in places where refrigerated cold rooms are available constant supply of electricity cannot be guarantee. Valle *et al* (1998) posited that some public health authorities and

buyers particularly in international fish trade markets now insist that value added fish products should pass through rigorous quality control measures and supplies should include a suitable test (Table 1) to show that the fish product is free from microbes before they are allowed into a country where the fish producer is targeting a specific market. Bellu (2013) defined a value chain as a set of interdependent economic activities and a group of vertically linked economic agents..Activities in fisheries value chain includes wholesale and retail marketing of fish; transportation of fresh and processed fish, fishing activities by fisher-folks, aquaculture production of fish and aquatic products in ponds including processing, preservation, value addition in different forms and products according to the demands or preferences of consumers. It should be noted here that in a value chain consumers choices are not always price driven because they may be willing to pay more for a value-added fishery product which they prefer or want depending on the country they live in or the market the value-added product is been sold. Thus, small-scale fisheries value chains include all the activities from pre-harvesting to harvesting and finally consumption of the product. To avoid losses and wastage along the value chain in Nigeria fisher-folks; aqua-culturist, processors, and companies involved in value addition need favourable government policies; skills, equipment and tools to help them do this important but delicate work of bringing value-added fishery products through the value chain to consumers who urgently need them in their daily diets for added nutritional nourishment and vitality.

WOMEN'S ROLE IN AQUACULTURE VALUE CHAIN

Nigeria's Fisheries and Aquaculture sub-sector is dominated by the male folk who are in control of the sector because of they have the ability of accessing funds for the purchase of fishing inputs and vessels. Women in spite of their large number and economic potentials, are relegated to the background with respect to policy making, decision taking and ownership of Fisheries and Aquaculture business enterprise in Nigeria. Rather they are made to play second fiddle to the male folks as subsistence farmers and small-scale business owners in the areas of processing and marketing.

Adiku (2019) in his study on the training needs of women vegetable farmers, stated that women have been the forefront, in the struggle to combat food crisis in Nigeria and the world at large. Their involvement in Fisheries and Aquaculture over the years in Coastal communities have been generally overlooked (2022). The degree of visibility of women's participation in decision making processes in fishing communities and fish value chains vary from country to country, depending on the prevailing social and cultural values of these countries. Power (2009) asserted that the various communities and fishing villages where women inhabit have largely excluded them from the decision-making processes at all levels of the fish value chain. According to FAO (2005) fish processing and trading is a major occupation amongst women fisher folks in Malawi. Most of the fish sold to distant markets is in dry form for easy transportation and storage. Manyungwa-Pasani *et. al.*, (2017); in a study done at Kachulu in Malawi noted the new intermediary role between fishers and processors/traders which is largely played by women (estimated at 70% to 90%) and this has been institutionalized in that community. These auxiliary intermediary actors are locally known as "macheucheu" and their role is to broker the sale of fish between fishers and processors/traders for a fee based on a pre-determined amount per number of tins sold/brokered for at any given transaction. In this role these women are presumed to negotiate not only the best price for the fish for both sides (fishers and processors) but also provide access to fish for the processors/traders in the sellers' market that is usually highly competitive. It was also noticed that majority of these "macheucheu" women at Kachulu were divorced or widowed with no financial muscle to run a proper business. The inhabitants of Kachulu Community in Malawi further reported that these "macheucheu" women got their powers for this role from being locals and inhabitants from within the community and no one from outside the community was allowed to participate in this unique role they played. In Nigeria smoking in artisanal fishing communities is predominantly done by women as confirmed by various workers apart from post-harvest ice storage, distribution, packaging and marketing (Agbontale and Eyo, 2005). Adeleke (2014) showed in his research findings that women have traditionally been occupied in pre and post-harvest processing of fish products, distribution and marketing of fish and other income generating non fisheries activities Bolarinwa 2014 noted that women are actively involved in oyster harvesting and fishing in coastal waters in Ondo State Nigeria

and they performed other functions as auctioneers, retailers, fish vendors and dealers in export driven value chains along coastal waters of Ondo State in Nigeria. Hitomi (2009) reported that in Japan women act as knowledge bearers of traditional fish processing and preservation techniques by playing a vital role in the transfer of knowledge from one generation to another. Women role in fish marketing especially retailing is very important for timely dissemination of catch and active participation of females in other modern fishery related activities such as environmental conservation; community-based resource management practices, mangrove replanting, micro-credit schemes, fisheries cooperatives and social works, all of which have greatly increased. Recent studies have shown that Nigeria fishers target informal markets by supplying fish products through local value chains. In the past artisanal fisheries have been associated with men but nowadays women activities and influence has increased as they now dominate distinct but complimentary roles that include pre and post-harvest activities. Women activities include handling, grading and processing fish at home; crew members on boats/canoes, collecting and retailing fish and fisheries products including active membership in cooperative societies. Other women in urban areas work as commercial processing fish workers; resource conservationist and community fishery related workers including activities like tourism and sport fishing for recreational purposes.

Harris and Vincent (2015) posited that despite all this work done by women their influence; marketization and commoditization activities in fishing communities and in the African fishing industry is largely undervalued by the value chain actors and the vital role they play is practically unseen and undocumented in fisheries management decisions. Aquaculture and fishery products have always provided a major source of food in many parts of Nigeria and fish has traditionally been the main source of animal protein in our diet especially amongst the low and middle level income groups. But this has drastically changed today because fish and aquaculture products are highly recommended for all income groups due to the nutritional benefits derived from consuming them.

CHALLENGES

One of the challenges faced by women in playing active role in the Fisheries and Aquaculture value chain and value addition is lack of skill and low technological know-how, in adopting modern methods of value addition. This has restricted most of them to only smoking and sun-drying of fish. In addition, where some of them are willing to adopt the new technologies, lack of or inability to access funds to purchase the requisite equipment for processing becomes a handicap.

CONCLUSION

Women play the vital role of value addition in aquaculture production and their activities in fisheries value chain during pre and post-harvest work cannot be under emphasized. They are involved in small scale fishing; processing, marketing, grading, handling, preservation, transportation, conservation, net mending activities, active participation in fisheries cooperative and conservation activities. Globally depending on the community or country women inhabit their role in the aquaculture value chain and value addition processes is multi-faceted and diverse remembering that majority of them have been excluded from the decision-making processes at all levels in the fish value chain. The vital role women play in aquaculture value addition and value chain should be encouraged with a renewed focus on targeting specific export markets where these products are highly demanded.

RECOMMENDATIONS

Government should initiate and implement policies that would create the requisite enabling environment that would encourage women participation and showcase the critical role they play in value addition. Workshops and trainings must be organized for fish processors to improve their skills in value-addition and fish processing so that fisheries and aquaculture products from Nigeria would be globally accepted and demanded in international markets. Fisheries and aquaculture extension officers trained to work amongst artisanal fisher-folks; fish farmers and the industrial fishing industry should disseminate research findings to the various workers in the industry and bring back problems from the field to research stations with the primary

focus of finding solutions to these problems. This would improve the socio-economic status and livelihoods of all participants in the fisheries and aquaculture value chain and industry.

Women should be encouraged to form cooperatives, to enable them raise funds to establish their own businesses. Furthermore, there should be a deliberate policy by the Government to give women financial incentives by way of keying them into the Federal Government's Central Bank of Nigeria (CBN) Anchor borrower' program.

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A REVIEW ON GENDER ROLES AND FACTORS INFLUENCING ADOPTION OF CULTURED FISHERIES TECHNOLOGIES IN KAINJI LAKE BASIN, NIGER STATE, NIGERIA

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ABSTRACT

Women play a major role in aquacultural production all over the world as labourers and managers of the production process; their roles are very restricted and often ignored. The objective of the review is to analyze the gender roles and factors influencing adoption of cultured fisheries technologies. Systematic review of existing literature from the year 2000 to 2025 was used for the study. A literature search was carried out and eligibility criteria were established. Studies that met the criteria were kept from search. The review was classified based on the eligible studies on state of aquaculture in Nigeria, gender role in fish production and factors influencing aquaculture technologies adoption. The review revealed that, there was shortfall of 0.20 million tonnes of fish to meet the domestic consumption in the study area. The study also revealed that both men and women participate actively in aquaculture production. More also, women headed households had negative influence on technologies adoption decisions, while age, level of education and extension contact had positive influence on adoption of technology. The study identified that there was dearth of information on cultured fisheries technologies adoption in Kainji Lake the study area. Therefore, to bridge the gap between the demand and supply of fish, the study recommended that appropriate fish technologies such as fry acclimatization, Pangus production, polyculture, monosex tilapia production, manual sorting, pond fertilization and appropriate stocking density should be encourage in the study area.

Key words: Gender, cultured fisheries, adoption, technologies and Kainji Lake

INTRODUCTION

Fish culturing entails the technique of producing desired kinds of fish in captivity and regulating them and their habitat to optimize development and reproduction. The fisheries sector remains an important source of food, nutrition, income, and livelihoods for hundreds of millions of people around the world (Food and Agriculture Organisation (FAO), 2019). With a greater emphasis on the nutritional value of food commodities, fish is recognized as a major nutrient-rich animal food source for a significant proportion of the nutritionally vulnerable population, outperforming most terrestrial animal foods. The contribution of

fishery activities to national economies is multifaceted. In addition to supplying food, the fishery sector contributes 5% out of the 24.17% agricultural sector contribution to nominal GDP in the fourth quarter of 2021 (National Bureau of Statistics (NBS), 2022). This helps to provide livelihoods for fisher folks and processors, serves as sources of foreign exchange and boosts government revenues through fisheries agreements and taxes (FAO, 2014). Although fish production is traditionally considered as a masculine enterprise, women's role in fisheries is complementary and crucial (Ovulate *et al.*, 2020). Women play a major role in aquaculture production such as labourers and managers of the production process; their roles are very restricted and often ignored. Gender is described as a socially determined attributes of men and women. It refers to the physical and biological differences between men and women (Porter, 2006). Gender is a useful socioeconomic variable in analyzing the roles, responsibilities, constraints, opportunities, and incentives of people involved in agriculture (Mafimisebi, 2007). In many developing countries Nigeria inclusive customary beliefs, norms and laws and /or unfavorable regulatory structures of the state reduce women's access to land and water resources, assets, technology and decision making (Porter, 2006; FAO, 2010), confining them to the lower end of supply chains within the informal sector (Guhathakurta, 2008). Aguihe *et al.* (2013) reported that women do almost all the breeding and management of improved catfish in Kainji Lake Basin (KLB), while men are only involved in feeding fry/fingerlings. However, women roles in breeding and management of improved catfish are being under estimated. It is widely recognized that women's engagement in aquaculture is numerous, significantly contributing to the overall well-being of household members; however, their contributions is not commensurate with the returns they get due to deep-rooted gender disparities in social, cultural and economic spheres. The biggest constraint to the effective recognition of men and women actual roles and responsibilities in cultured fish production is the scarcity of gender disaggregated data available. In addition, with the continuous migration of able and energetic youths from rural to urban areas in search of paid jobs has reduced the labour availability for cultured fish production. This has also cut off rural youth's involvement in agriculture, leaving farming activities on the hand of aged men and women.

METHODOLOGY

Systematic review was adopted for this study. Some selected literature on gender roles and factors influencing cultured fish production were sorted from research gate, Google, Google scholar and Semantic Scholar. A database was created for the entire journal and conference papers searched. A total of 270 journals and conference papers published within 2000 – 2025 were obtained. The articles were sorted based on the eligibility criteria established to choose relevant articles for the review, and irrelevant materials were excluded from the database. Eighty four research articles and book chapters containing relevant and useful information were among the materials used for the review. The study was carried out in three phases. The first phase was brief description of state of aquaculture in Nigeria. The second phase dwells on gender role in fish production while the third phase involved studies on factors that influence adoption of aquaculture production technology.

State of Aquaculture in Nigeria

Nigeria is the second-largest aquaculture producer in Africa with a production output of about 300, 000 tons annually and largely dominated by catfish culture (Ozigbo *et al.*, 2014; FAO 2016, 2018). Aquaculture production began in Nigeria over five decades ago (Olagunju, 2007). However, it has not been able to close the gap between domestic consumption and production output (Ozigbo *et al.*, 2014). Aquaculture development in Nigeria was primarily driven by socio-economic objectives such as supplementary income generation, improving nutrition in rural areas and employment creation, until recently, when aquaculture's focus was changed and geared towards addressing domestic fish supply gaps in order to reduce fish importations (Ozigbo *et al.*, 2014). Fish accounts for about 40% of animal protein consumed, with a per capita fish consumption of 13.3 kg (World Fish, 2018). In Year 2021, Nigeria still fall short of fish supply up to the tune of 0.20 million tonnes despite being the leading producer of fish in Africa as revealed in (Table 1).

Table 1: Projected population and fish demand/supply from 2000 to 2025 in Nigeria.

Year	Population (Million)	Fish demand (Million tons)	Fish supply (Million tons)	Shortfall (Million tons)
2000	114.40	0.87	0.53	0.34
2001	117.60	0.89	0.57	0.32

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2002	121.00	0.92	0.61	0.31
2003	124.40	0.95	0.65	0.30
2004	127.90	0.97	0.69	0.28
2005	131.50	1.00	0.73	0.27
2006	135.20	1.03	0.77	0.26
2007	139.10	1.06	0.81	0.25
2008	143.00	1.09	0.85	0.24
2009	147.10	1.12	0.89	0.23
2010	151.20	1.15	0.93	0.22
2011	155.50	1.18	0.96	0.21
2012	159.90	1.22	1.00	0.22
2013	164.40	1.25	1.04	0.21
2014	169.10	1.29	1.08	0.21
2015	173.90	1.32	1.12	0.20
2016	178.80	1.36	1.16	0.20
2017	183.30	1.39	1.20	0.19
2018	189.00	1.44	1.24	0.20
2019	194.40	1.48	1.28	0.20
2020	199.90	1.52	1.32	0.20
2021	212.60	1.56	1.36	0.20
2022	218.40	1.61	1.40	0.21
2023	224.40	1.65	1.44	0.21
2024	230.50	1.70	1.48	0.22
2025	235.80	1.75	1.52	0.23

Source: Amosu *et al.* (2016)

Role of Gender in Fish Production

Women have important roles in aquaculture production, although these roles are frequently overlooked or "hidden" in value chain analysis (Rutaisire *et al.*, 2017). The fact that women engage in aquaculture production may not guarantee their involvement in the final decisions regarding pond management tactics, product usage, and sales. Similar to this, their involvement is obscured by the fact that male households typically hold formally or informally ownership of ponds and land. Literatures suggested that the gender division of aquaculture production roles depend on the existing division of labour and gender norms (relating to what work is considered appropriate for women and for men) in a particular geographic location. The gender roles and economic differentials in aquaculture of KLB Niger State were examined by Julius *et al.* (2021). The findings revealed that the men and youths (86%) had direct access to land through inheritance and purchase while the women (61%) accessed land through a family and relations. The adult men and male youths performed majority of the gender roles such as preparation of ponds, fingerlings stocking, fish management and post-harvest activities while the adult female and female youths actively engage in fish management, liming and grading. Economic indicators show that the men and youths have higher returns on investment than the women. The study recommended that women should be organized in groups for empowerment. This will enable them utilize their collective strength through division of labour in fish farming. In a similar study Omitoyin *et al.* (2020) examined gender participation in aquaculture in Lagos State, Nigeria. Findings revealed that both male and female fisher folks were in their active age with tertiary education level. It was also revealed that male fish farmers engages in subsistence fish farming while majority of the females are engaged in aquaculture to augment their household income needs. Majority (75%) of male respondents engages in harvesting while most (47%) of the females are involved in processing.

Conclusion

The study reviewed the gender roles and factors influencing the adoption of cultured fish technology in Kainji Lake Basin, Nigeria. From the review of related literature, it can be concluded that despite Nigeria being the second-largest aquaculture producer in Africa, there is still a shortfall of fish supply to meet domestic consumption. Also, men and women participate actively in aquaculture production (men involved in preparation of ponds, fingerling stocking, fish management, and post-harvest activities, while the women and female youths were actively involved in fish management, liming, and grading). More so, it can be

concluded that women-headed households had negative influence on technology adoption decisions, while age, level of education, and extension contact had a positive influence on the adoption of

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EMPIRICAL STUDY OF THE DRIVERS AND STRATEGIES FOR MANAGING FISHERIES CONFLICT IN COMMUNITIES IN THE FADAMA AREAS OF ADAMAWA STATE

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Abstract

This study investigated the drivers and strategies for managing fisheries conflicts in Fadama fishing communities in Adamawa state. The study employed descriptive research design and employed a purposive sampling technique to select 309 fishers from 4 fishing communities in the Fadama areas of Adamawa state which include: Bagale, Rugange, Bilanchi and DansinBiratiye. The categories of participants selected for

the study include: community leaders (37); male fishers (134); female fishers (46); fish marketers (49) and fish processors and preservers (41). Data was collected through a quantitative questionnaire and analysed through standard deviation. The study established the factors that drive fisheries conflict in the fishing communities in Adamawa state to include: competition over jurisdiction between local and outside fishers; stealing of fishing gears; violation of community fishing rules and regulations; volume of water bodies due to effects of climate which heighten competition between actors in fishing communities; and limited fish resources among others. In order to constructively manage fisheries resources in sustainable manner, compromise and collaboration conflict management strategies were recommended to promote a culture co-management of fisheries resources in the Fadama areas of Adamawa state and other areas where fisheries conflict are endemic in Nigeria.

Key words: Fisheries, conflict management, drivers, strategies, fadama

INTRODUCTION

In Nigeria, Nwafili and Tianxiang (2007) observe that out of the estimated 120 million people in Nigeria in 2000, about one percent engages in fishing and over 24 million Nigerians depend on fisheries for their livelihood yet Nigeria imports over 600,000 metric tonnes of fish annually (Central Bank of Nigeria, 2007). Nigeria's population has grown now to 198 million (United Nations, 2017) and it is expected that more Nigerians will be depending on fisheries for their livelihoods. Generally, fish resources provide the main source of sustenance, assets and investment capital, over 60% of the communities are engage in fishing as their main source of livelihood (Ladu and Neiland, 1997).

In Adamawa state also, fishing provide huge employment and livelihood sustenance for many people residing in fishing communities especially those along the banks of River Benue and the Fadama areas. The huge number of people engaged in fisheries in the state presupposes that the interests of these various actors would often times engender conflict which may impact negatively on the fishing activities. For instance, a study conducted by the Food and Agriculture Organisation (FAO), observe that conflicts take place in fisheries when groups or individuals seek the same resource using different methods or try to utilize the same space for their activities with either party seeking dominance (FAO, 2003). This view expressed by FAO is informed by what Desloges (1997) believe result to conflict when he noted that conflicts originate in the different perceptions of the parties involved regarding who should manage, use and benefit from a resource.

Notwithstanding, conflict is not necessarily bad as it can be a social force or catalyst for change and development when it is constructively channeled into productive activities. However, a poorly managed conflict can be counter-productive to social interactions and productive activities. The massive impacts of climate change, desertification and explosion of human population have all been putting pressure on fishing communities in the Fadama areas of Adamawa state with the consequent potential for driving violent conflicts among the various fishing actors in the inland fishing communities in the Fadama areas of Adamawa state. The main purpose of this study is to examine the drivers and strategies for managing fisheries conflict in the Fadama fishing communities of Adamawa state.

Drivers of Conflict Among Fisherfolks

There are many factors that drive fisheries conflict. Warner (2000) identify four issues that may explain the emergence of conflict, demographic change (a sharp influx of newcomers into a community); natural resource competition (increased which dependence upon the natural resources which increases competition for space and resources); developmental pressures (as government policy switches from livelihood protection to food production); and structural injustices (changes in legislation that deny or severely restrict access to a resource by dependent groups of society).

Conflict Management Strategies

There are many types of conflict management strategies ranging from those that emphasize cooperativeness and assertiveness to those that indicate low concern and high concern. Blake and Mouton (1964) suggest the five conflict management strategies which include: withdrawal, smoothing, compromise, forcing and problem-solving. These five styles used to manage conflict are: avoiding (low assertiveness and low cooperation); accommodating (low assertiveness and high cooperation); competing (high assertiveness

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and low cooperation); compromising (medium assertiveness and medium cooperation) and collaborating (high assertiveness and high cooperation).

METHODOLOGY

A descriptive survey design was adopted for the study. The participants of the study consisted of 309 (three hundred and nine) fishers purposively drawn from four fishing communities in the Fadama areas of Adamawa state. The study areas are 4 fishing communities in the Fadama areas of Adamawa state. These communities are: Bagale, Rugange, Bilanchi and DansinBiratiye. The number of participants drawn from these fishing communities are 16 from Bagale, 86 from Rugagng, 32 from Bilanchi and 175 from DansinBiratiye. The categories of participants selected for the study include: community leaders (37); male fishers (134); female fishers (46); fish marketers (49) and fish processors and preservators (41). A structured questionnaire containing 46 items was designed and used to elicit data on “Conflict Drivers and Conflict Management Strategies of Fishers in Fadama Areas of Adamawa State”. The quantitative data elicited was analysed through the use of descriptive statistics such as mean and standard deviation.

RESULT AND DISCUSSION

The results presented are based on three hundred and nine (309) data collected on the topic on - Managing Conflict in Communities in Fadama Areas of Adamawa State. Descriptive statistics were used to analyze the demographic characteristics of the respondents and all sections of the questionnaires, while mean and standard deviation was used to test the research questions.

Demographic Data

Table 1 Distribution of Demographic Characteristics of respondents

Demographic factors		N	%
Fadama Area	Bagale	16	5.2
	Rugange	86	27.8
	Bilanchi	32	10.4
	DasinBwatye	175	56.6
Gender	Male	252	81.6
	Female	57	18.4
Age	18 – 30 yrs	123	39.8
	31 – 40 yrs	111	35.9
	41 yrs and above	72	23.3
	Undecided	3	1.0
Education	Primary school leaving certificate	82	26.5
	WASSCE/SSCE	119	38.5
	NCE/OND Diploma	8	2.6
	Others	94	30.4
	Undecided	6	1.9
Marital status	Single	81	26.2
	Married	189	61.2
	Divorced	18	5.8
	Widow/Widower	17	5.5
	Undecided	4	1.3
Religion	Christianity	224	72.5
	Islam	68	22.0
	Traditional Religion	16	5.2
	Undecided	1	0.3
Respondents from fishing communities	Community leaders	37	12.0
	Male fishers	134	43.4

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	Female fishers	46	14.9
	Fish marketers/buyers	49	15.9
	Fish processing and preservation	41	13.3
	Undecided	2	0.6
How long have you been involved in fisheries sector	1 – 5 years	17	5.5
	6 – 10 years	63	20.4
	11 – 15 years	102	33.0
	15 years and above	125	40.5
	Undecided	2	0.6
Total		309	100

Research Question 1: What is the nature of fisheries conflict in communities in Fadama areas of Adamawa State?

Table 2 Nature of fisheries conflict in communities in Fadama areas of Adamawa State

SN	Items	Strongly Agree /Agree	Strongly disagree /Disagree	Mean	Std
1	Conflict between local fishers competing for access to fish resources	267 (86.4%)	42 (13.6%)	1.86	0.34
2	Conflict between fishers and fish traders	223 (72.2%)	86 (27.8%)	1.72	0.45
3	Conflict between fishers and traditional local authority	192 (62.1%)	117 (37.9%)	1.62	0.49
4	Conflict between local fishers and outside fishers	243 (78.6%)	66 (21.4%)	1.79	0.41
5	Conflict between fishers and government authorities	239 (77.3%)	70 (22.7%)	1.77	0.42

The table of means and standard deviations above shows that all the mean values exceeded the cut-off point of 1.5 thus indicating that respondents strongly agreed to all the items on the nature of fisheries conflict in communities in Fadama areas of Adamawa State. These findings on the nature of fisheries conflicts in the Fadama areas of Adamawa state is consistent with studies such as Bennett et al., 2001; Warner, 1992 and 2000; Mahfuzuddin, Nerissa, Viswanathan, Len, and Pido, 2006 and Charles, 1992 have all identified and categorized the different types of fisheries conflict. These categorizations are done based on the types of actors involved in the conflict and it makes it easy for identification of the parties and issues in the conflict for proper resolution.

Research Question 2: What are the drivers of fisheries conflict in communities in the Fadama areas of Adamawa State?

Table 3 Drivers of fisheries conflict in communities in the Fadama areas of Adamawa State?

SN	Items	Strongly Agree /Agree	Strongly disagree /Disagree	Mean	Std
1	Competition between fishers over access to fish resources	255 (82.5%)	54 (17.5%)	1.83	0.38
2	Competition over fishing boundaries or jurisdiction between local and outside fishers	271 (87.7%)	38 (12.3%)	1.88	0.33
3	Stealing of fishing items (boat, net, paddle, fish etc) by fellow fishers	252 (81.6%)	57 (18.4%)	1.82	0.39
4	Violation of community rules and regulations on fishing by fishers	244 (79.0%)	65 (21.0%)	1.79	0.41
5	Mutual suspicion and hatred between fishers	278 (90.0%)	31 (10.0%)	1.90	0.30
6	Reduced catches of fish by fishers creates frustration desperation to catch fish	260 (84.1%)	49 (15.9%)	1.84	0.37

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7	Misunderstanding amongst fish traders or between fish traders and fishers over the purchase or selling of fish (i.e. fish pricing)	231 (74.8%)	78 (25.2%)	1.75	0.44
8	Struggling for the same stock of fish	196 (63.4%)	113 (36.6%)	1.63	0.48
9	Increase migration of fishers who are searching for better fishing grounds	183 (59.2%)	126 (40.8%)	1.59	0.49
10	Running into net of other or casting of net over others	201 (65.0%)	108 (35.0%)	1.65	0.47
11	Reduction in the volume of water bodies due to effects of climate which heighten competition between actors in fishing communities	188 (60.8%)	121 (39.2%)	1.61	0.49
12	Limited fish resources in water bodies in Adamawa state	271 (87.7%)	38 (12.3%)	1.88	0.33

The table of means and standard deviations above shows that all the mean values exceeded the cut-off point of 1.5 thus indicating that respondents strongly agreed to all the items ;on the drivers of conflict in communities in the Fadama areas of Adamawa State. The findings are consistent with studies such as Bennett et al. (2001) and Warner (2002) that clearly highlights the drivers of fisheries conflicts. More importantly is the role that scarcity of fish resources play in driving fisheries conflicts as studies such as Coser (1967); Barbier and Homer-Dixon (1996) and Homer-Dixon (1991, 1994) found out that resource scarcity is the catalyst that highlights other underlying problems in society

Research Question 3: What are the conflict management strategies for resolving conflict in fishing communities in Adamawa State?

Table 4 Conflict management strategies for resolving conflict in fishing communities in Adamawa State

SN	Items	Strongly Agree /Agree	Strongly disagree /Disagree	Mean	Std
1	I try to give in to the demands of the other party so that peace can reign (Accommodation)	184 (59.5%)	125 (40.5%)	1.60	0.49
2	I pursue my goals without cooperating with the other party to resolve the issues in the conflict (Competition/Domination)	162 (52.4%)	147 (47.6%)	1.52	0.50
3	I Ignore and refuse to confront the conflict situation to resolve it (Avoidance/Denial)	170 (55.0%)	139 (45.0%)	1.55	0.50
4	We agree to confront the issues in conflict by exploring our differences and resolving them together (Collaboration)	212 (68.6%)	97 (31.4%)	1.69	0.47
5	I use give and take so that we can compromise to resolve the issues	222 (71.8%)	87 (28.2%)	1.72	0.45

The table of means and standard deviations above shows that all the mean values exceeded the cut-off point of 1.5 thus indicating that respondents strongly agreed to all the items on the conflict management strategies for resolving fisheries conflict in communities in the Fadama areas of Adamawa State. The involvement of the traditional structures in the management of fisheries conflict is based upon the FAO Code of Conduct for Responsible Fisheries (1995) that advocates the inclusion of local communities in management of their fisheries resources. Amason (2007) suggested some remedies towards alleviating fisheries conflicts which the traditional platforms could leverage on in facilitating resolutions of fisheries conflicts. These remedies include: 1) fishing licenses, 2) sole ownership, 3) territorial use rights in fisheries (TURFS), 4) individual catch quotas, and 5) community fishing rights (Amason, 2007).

Conclusion

This study has examined the factors that drive fisheries conflict and the strategies employed to manage fisheries conflict in communities around the Fadama areas of Adamawa state. The study brought to the fore the fact that fisheries conflict are largely driven by competitive behaviours of fishers. The consequences of fisheries conflicts can be far-reaching as they can threaten food and job security as well as economic development of countries that rely on the sector if they are not timely and effectively managed. The study therefore argues that fisheries conflict can only be managed in a sustainable manner if the actors embrace cooperative behaviours rather than the competitive behaviours that usually drive fisheries conflict. A veritable platform that can be used to facilitate and encourage cooperative behaviours is the traditional institutional structures present in fishing communities. The traditional structures are best suited to promote the culture co-management of fisheries resources because they are the custodian of the inland water bodies in Fadama areas of Adamawa state.

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INSECURITY AND CHALLENGES DETERRING WOMEN PARTICIPATION IN FISH PRODUCTION FOR SUSTAINABLE DEVELOPMENT IN TARABA STATE

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ABSTRACT

The present study identified the major threat and challenge deterring women from participation in the supply chain of freshwater fishery in Taraba state, Nigeria. A total of 200 questionnaires were randomly distributed in (10) Local Government Areas of the state to collect relevant research data, while 180 were retrieved. Data collected were analyzed with descriptive statistics. The results obtained in table 1, revealed a drastic decreased in the trend of participation among the old women (8.3%), while kidnappings (63.9%) and lack of electricity (44.4%) as depicted in tables 2 and 3 respectively, were the major threat and challenge hampering the dilatation of aquaculture and fisheries in the study area. To overcome these and other threats and challenges, government must be proactive in dealing with security issues and threats, through training, modern methods of intelligence gathering and intelligence sharing, logistics and deploying advanced technology in managing security challenges and Taraba state government should also collaborate with Federal government to execute Mambila Hydro-electric power project so as to overcome the existing lack of electricity in the study area as well as the problem of erratic power supply in the country at large.

Key Words: Insecurity, Challenges, Women participation, Fisheries, Taraba State, Nigeria.

INTRODUCTION

Women in Nigeria have been playing significant roles in national security in spite of cultural, religious and demographic challenges facing them. Women are the most affected by uncertainties and different types of insecurities in all the geographical regions of Nigeria including the Federal Capital Territory (Afolabi, 2022). Regardless of the challenges aforementioned, women have been reported to play a vital role in fishery related activities around the world, especially in the coastal environment, where these activities are classified majorly in three ways: fishing, processing and marketing (Olufayo, 2012). Their role in food production like fish processing and preservation has become more relevant as a way of reducing poverty and enhancing food security. Worldwide, women in fishing communities have been observed to participate actively in fisheries and also play a part in the maintenance of their families (Nwabeze *et al.*, 2013). In the European countries for instance, women control 39% of the fish industry making a huge amount of money for themselves and their families (Aquilar, 2002). According to Olufayo (2012), in Nigeria, women play a major role in aquaculture as both labourers and managers of the production process. The crucial engagement of women in natural resources-based occupation such as fisheries in the rural communities has long been accepted but not recognized and not valued as men contribution (Obeta *et al.*, 2007). However, fish production is customarily considered as masculine venture, women role in fish related activities is though supportive, is imperative and indispensable (Chiffe *et al.*, 2011a). Their role is repeatedly being ignored and relegated, consequent of primordial systems of social settling, that is prevalent in the rural areas of many developing countries like Nigeria (Ibrahim *et al.*, 2011). Above all, insecurity issues are the major factors limiting women participation in economic activities such as inland and coastal fishery practices. According to Feminist Womenifesto Group (2021), insecurity jeopardized the continued survival of the country, and every citizen could be affected. Insecurity is a state of lack of protection from danger in which one is not at ease with oneself. It is a situation that involves fear, anxiety, worry and apprehension. Insecurity is the state of being open to danger or risk and the feeling of being unsafe (The NROC Project, 2021). There are various types of insecurity which include bodily, emotional, food, economic, political, and environmental insecurity among others, but the physical insecurity involves banditry, killing, kidnappings, mutilating and farmer-herders clashes which appeared alarming in recent times and women participation in the supply chain of freshwater fishery seemed decreasing. Therefore the objective of this present study is to investigate some factors hampering the dilatation of aquaculture and fisheries with the aim of identifying some major threat and challenge deterring women participation in fish production for sustainable development in Taraba State.

MATERIALS AND METHODS

Description of the Study Area

Taraba state falls within the middle belt zone, thus, preservation system will differ from one zone to another hence climatic diversities were recognized in the three zones of the country. Taraba state covers a land area of approximately 60,000km² and a land mass total area of 60,291.82km² which makes it the third largest in the country after Niger and Borno state (Taraba State Government, 2014; 2018). The state lies between latitude 6° 30" and 8° 30" north of the equator and between longitude 9° 00" and 12° 00" east of the Greenwich Meridian. The state shares boundaries with Bauchi and Gombe state in the north, Adamawa state in the east, Plateau state in the north-west, Benue and Nasarawa state in the west, and shared international boundary with the Republic of Cameroon in the south (Fig. 1). The population of the state in 2006, according to 2006 census figures released by the National Population Commission (NPC), was Two millions three hundred thousand, seven hundred and thirty six people (2,300,736). However, the current projection of the population of the state as at 2016 is Three millions people (TSG. Diary, 2018). It is divided into sixteen Local Government Areas (LGAs) and three Senatorial districts (Taraba north, central and south). Taraba State is regarded as Nature's Gift to the Nation because of its abundant natural resources endowment. The state is well endowed with abundant solid mineral resources, surface water resources, arable and grazing land. The major occupation of the people of Taraba State is Agriculture.

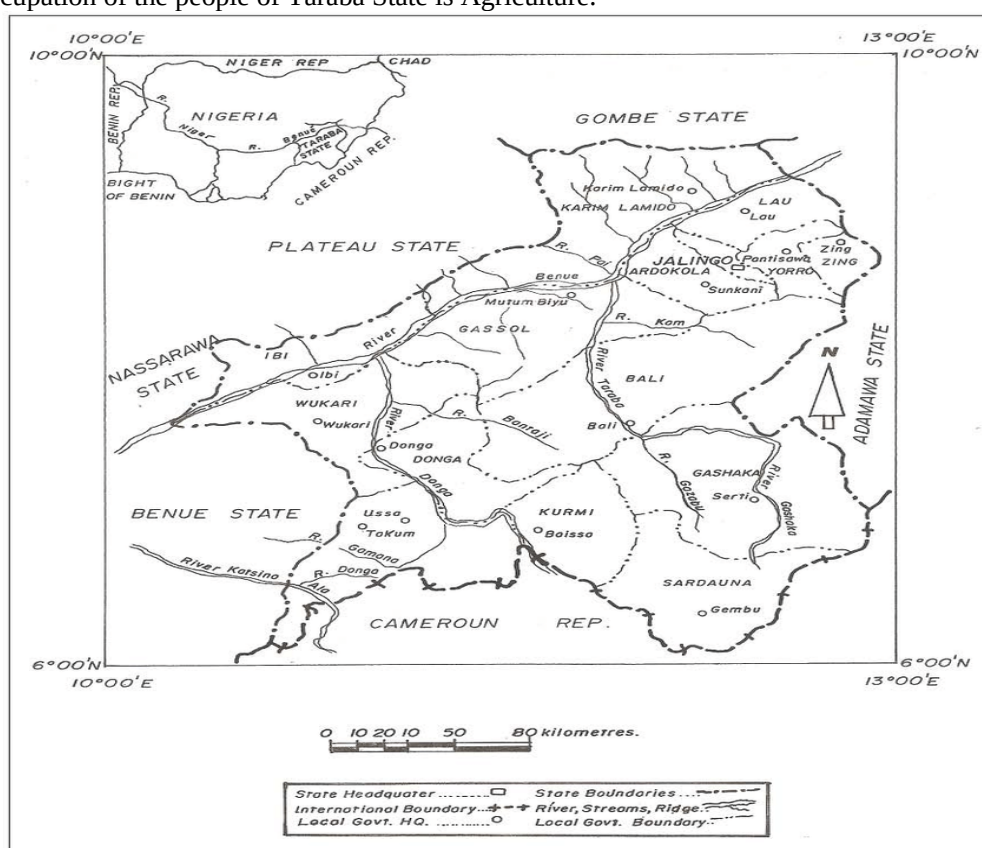


Figure 1: Map of the Study area (Taraba State)

Sampling procedures

The study was conducted between March and August, 2022. A preliminary survey was carried out to identify the major threat and challenge deterring women participation in fisheries and aquaculture in the state. The survey was conducted and ten communities from ten Local Government Areas across all the three senatorial districts (Northern, Central and Southern zone) of Taraba state were selected. The communities selected in Northern zone include Jen in Karim Lamido LGA, Kunini in Lau LGA, Yelwan Tau in Jalingo LGA and Manerewo in Ardokola LGA; the Central zone include Wurbo in Bali LGA, Garin Isu in Gashaka LGA and Sheka in Gassol LGA; while Southern zone comprises Kashin Bila in Takum LGA, Jibu in Wukari LGA and Dampar in Ibi LGA. A total of Two hundred (200) fishmongeresses with many years of experience were randomly selected with the help of traditional leaders of the various communities. The sample size was calculated using Taro Yamane's formula (1967). The survey was conducted using Investigative Survey Research Approach (ISRA) Method (Anazodo *et al.*, 1986). Information were collected through interviewed

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at fish landing spots, smoking hut, houses and market squares of the selected fisheries communities and structured questionnaire was also used to extract the socio-economic characteristics (personal information) like age, marital status, household numbers, educational level, years of experience in fishmongery and some challenges deterring women participation in the supply chain of freshwater fisheries in the study area.

Statistical Analysis

The tools of analysis used for the study was descriptive statistics of the explanatory variables (both qualitative and quantitative). This involves the use of central tendency such as mean frequency distribution and percentage.

RESULTS AND DISSUSSION

The Result of Socio-economic Characteristics of respondents in Taraba state is shown in Table 1. The results obtained revealed that old women (age 51 and above) are the set with the least percentage (8.3%), indicating that old women venturing into supply chain of freshwater fishery were drastically decreasing. This may be due to fear of being attacked and other challenges like lack of finance, lack of electricity, lack of cooperative society, dearth of modern technologies, poor transportation, and poor access to credit facilities. Furthermore, majority (52.8%) of the respondents interviewed in the study were married. This result is supported the finding of Nwabeze *et al.* (2013) that reported highest percentage of married women participation in fisheries of Kainji Lake basin while majority (41.7%) of respondents had no educational experience. This result is in line with that of Cliffe *et al.*, (2015) that women from riverine areas are not well-read, with little or no education. Most of the respondents (39.4%) had eleven to fifteen years of experience, and the highest percentage (42.2%) of respondents had between five to seven household numbers while most of them (44.4%) were involved in the supply chain of freshwater fisheries primarily to meet their daily needs and support their husbands. The reason why school fees were recorded lowest may be due to lack of their interests towards education. As depicted in Table 2 and 3, kidnappings (63.9%) and lack of electricity (44.4%) were the major threat and challenge deterring women participation in the supply chain of freshwater fisheries.

Conclusion and Recommendation

The study has revealed sudden strong rise of criminal activities and some challenges deterring women participation in fish production for sustainable development in Taraba state. The major threat and challenge affecting the supply chain of freshwater fisheries in the study area were kidnappings and lack of electricity. To overcome these and other threats and challenges, the following actions are recommended. Government must be proactive in dealing with security issues and threats, through training, modern methods of intelligence gathering and sharing, logistics and deploying advanced technology in managing security challenges and there should also be an open dialogue among Tarabans, cutting across all ethnic groups in order to negotiate and proffer ways of living in peaceful coexistence so that Taraba would be able to overcome its threats of insecurity. Taraba state government should also collaborate with Federal government to execute Mambila Hydro-electric power project so as to overcome the existing lack of electricity in the fishing communities of Taraba as well as the problem of erratic power supply in the country at large.

Acknowledgement

My unreserved gratitude goes to all the traditional leaders of the fisheries communities visited and also to all my research assistants during the field work and questionnaire administration.

Table 1: personal characteristics of respondents (n=180)

Variables	Frequency	Percentage (%)
Marital status:		
Single	45	25
Married	95	52.8
Divorce	25	13.9
Widowed	15	8.3
Age (Years):		
30 and below	32	17.8
31 – 40	78	43.3
41 – 50	55	30.6
51 and above	15	8.3
Level of education:		
Did not go to school	62	34.4

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Primary school	75	41.7
Secondary school	30	16.7
Tertiary	13	7.2
Experience in the supply chain		
10 and below	34	18.9
11 – 15	71	39.4
16 – 20	50	27.8
21 – above	25	13.9
Family size:		
4 and below	26	14.4
5 – 7	76	42.2
8 – 10	57	31.7
11 and above	21	11.7
Reasons for involvement in fishmongery:		
Meet daily need	80	44.4
Payment of school fees	10	5.6
Generate savings	56	31.1
Purchase of goods	34	18.9

Source: Field, 2022

Table 2: Criminal activities discourages women participation in fish production in the study area

Variable	Categories	Frequency	Percentage (%)
Threats	Farmer-herder crisis	25	13.9
	Banditry	40	22.2
	Kidnappings	115	63.9

Source: Field, 2022

Table 3: Challenges deterring women participation in the supply chain of fisheries in the study area

Variable	Categories	Frequency	Percentage (%)
Challenges	Dearth of modern preservation kilns	40	22.2
	Lack of finance	35	19.5
	Lack of electricity	80	44.4
	Poor transportation	25	13.9

Source: Field, 2022

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ADDENDUM

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Suppression of Gonadal Development in the African Catfish (*Clarias gariepinus*) Via a Diet Containing Paw-Paw Leafmeal (*Carica papaya*)

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ABSTRACT:

Four hundred and eighty (480) fingerlings of *Clarias gariepinus* (Burchell, 1822) of mean initial weight 3.5 ± 0.04 g were stocked in twelve (12) glass aquaria (each tank containing 40 fish). Each of the aquarium measured 70cm (L) x 40cm (W) x 40cm (H) and contained 40 litres of water maintained at a pH range of 6.99 ± 0.3 to 7.00 ± 0.07 ; DO range of 3.4 ± 0.18 to 3.55 ± 0.16 mg/l; Temperature range of 28.99 ± 0.04 to 29.33 ± 0.05 °C and NH₃ concentration range 0.01 ± 0.002 to 0.02 ± 0.002 mg/l through a 22week sampling period. Fish fed with POKER (Commercial feed) formed the control Treatment (T₁). Fish fed other Diets formed T₂ & T₄ while a formulated feed containing pawpaw (*Carica papaya*) leafmeal served as the experimental feed – Treatment 3 (T₃). All the four treatments had 3 replicates each: T₁R₁, T₁R₂, T₁R₃; T₂R₁, T₂R₂, T₂R₃; T₃R₁, T₃R₂, T₃R₃ & T₄R₁, T₄R₂, T₄R₃. The diets D₁, D₂ D₃ & D₄ were iso-nitrogenous at a mean of 41.81 ± 0.04 (CP) and fed to *Clarias gariepinus* twice daily at 5% body weight. Mean Gonado-Somatic index of male and female *C. gariepinus* at final mean weight 414.55 ± 7.13 g were significantly different ($P < 0.05$), T₃ having lesser values than the control (T₁), T₂ & T₄. This indicates that inclusion of pawpaw leafmeal in fish feed can reduce gonadal growth while enhancing somatic growth which is the desire of every fish – as well as other animal – farmers.

KEY WORDS: Gonadal Development Suppression, African Catfish, Diet, Pawpaw Leafmeal

INTRODUCTION

The determination of nutritional indices of food substances on reared animals as well as the effects of the food constituents on somatic and gonadal development is key in fish culture as in another animal husbandry. For a feed to be ascertained good for feeding, it must be put to a feeding trial test on the given experimental animal (Udo et al., 2011). Numerous workers have researched into several fish nutrition and dieting (Auta et al., 2013; Ekanem et al., 2012 a and b; Eyo et al., 2013 a and b).

Information on gonadal development in fishes have been proposed to be useful indicators of reproduction success in terms of hatchability, egg and sperm quality and fry quality (Eyo et al., 2013; Eyo et al., 2014). Research findings also indicate that gonadal development in cultivated fish species have been found to be influenced by nutrition (Adewumi, 2005; Izquierdo et al., 2001; Ekanem and Ekanem, 2010; Sotolu and Kigbu, 2011; Ekanem et al 2012; Asuquo et al 2012; Ekanem et al; 2013 ; Eyo et al., 2014). While feeding *Clarias gariepinus* with varying levels of protein in diets, Ibim and Sikoki (2014) found 40% crude protein (cp) level as ideal for enhancing gonadal development and spawning. They then recommended this for cost effective brood fish management and gonadal development for year-round seed production. Mahmud et al (2016) also state that Gonado-Somatic Index (GSI) values are indicators of the status of gonadal development and maturity. A fecund and gravid female fish (eg *C. gariepinus*) may contain eggs taking one fifth ($1/5$) of the total mass of the fish. This is not good for fish propagated for flesh consumption. Suppression of gonadal development then becomes inevitable. Feed ingredients containing anti-fertility substances such as paw-paw leaf are therefore exploited in fish feed formulation to suppress egg production but enhance somatic growth. Paw-paw leaf (*Carica papaya*) meal is reported to contain a broad spectrum of phyto-chemicals including saponins and steroids (phyto estrogens) which relate with sex hormones (Okwu and Okwu, 2004).

The African sharptooth catfish or *Clarias gariepinus* is a species of catfish of the family claridae, the air breathing catfishes. It is named after its locality-the Gariep river, a Hotentot name for Orange River

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in South Arica (Daniel and Rainer 2014). *Clarias* comes from the Greek word Chlaros which means lively in reference to the ability of the fish to live for a long time out of water (Froese et al , 2014). It is the most widely distributed fish in Africa (Skelton, 2001). They are found throughout Africa and the Middle East and live in fresh water, lakes, rivers, swamps as well as human-made places such as ponds or even urban sewage systems, in tropical to temperate regions. The dominance of catfish species in aquaculture is particularly pronounced in Nigeria and Uganda and being the largest producer of catfish in Africa, Nigeria even imports catfish feeds from as far away as Northern Europe. (FAO, 2012)

Paw-paw leafmeal constitute a part of the unconventional stuff combined with conventional feed ingredients in the diets of animals to cut down cost of production in addition to their nutritional values. Also, where necessary, some of these unconventional feed stuffs are applied to check gonadal development in preference to somatic growth. Paw-paw (*C. papaya*) seeds and leaves have been found to exhibit anti-fertility and abortifacient properties as it is used in controlling fertility in Nile tilapia, *Oreochromis niloticus* (Okwu and Okwu 2004). The leaves of pawpaw (*C. papaya*) are high in protein but low in fibre; with 32.4% and 4.2% respectively for CP and CF (Olaniyi and Solau 2013).

The results obtained from this research work showed that male and female fish fed with a diet containing pawpaw leafmeal had significantly ($P<0.05$) lower mean GSI than fish fed diets without this ingredient. This variation is attributable to the differences in the experimental diet composition. The anti-fertility agent in the paw-paw leafmeal was found to be the cause of the suppression of gonadal development. This practice of pawpaw leaf inclusion in fish diet is analogous to castration of farmed and domesticated land mammals which enhances bodily growth.

MATERIALS AND METHOD

Forty (40) fingerlings of *Clarias gariepinus* with mean individual weight of 3.507 ± 0.04 g were stocked in twelve glass aquaria measuring 70cm (L) x 40cm (W) x 40cm (H) containing 40 litres of water each. These tanks served as reservoirs for four experimental treatments with three replicates each. This experimental design was maintained in a Zoology Laboratory of the University of Calabar, South Eastern Nigeria.

Various feed ingredients were processed and mixed together to form three different diets, D₂, D₃ & D₄ and PODDER (commercial feed) was also procured and used as a control diet, D₁. The Diets formulated from locally sourced ingredients as shown on Feed Composition table (Table 1) were subjected to Proximate Analysis.

Table 1: Amount of Experimental feed ingredients in Grams per Kilogram (g/kg)

DIET	INGREDIENTS															
	GM	SM	BLM	CF	BEM	BM	CAF	PLM	MF	SBM	FM	CLM	Nacl	Lys	Meth	Vit
D2	277.2	277.2	277.2	108.4	-	-	-	-	-	-	-	-	5	10	10	15
D3	-	-	-	-	257.6	257.6	167.2	257.6	-	-	-	-	5	10	10	15
D4	-	-	-	-	-	-	-	-	72.1	289.3	289.3	289.3	5	10	10	15

Key: GM = Groundnut meal, SM = Shrimp meal, BLM = Banana leafmeal, CF = Cocoyam flour, BEM = Bean meal, BM = Blood meal, CAF = Cassava flour, PLM = Pawpaw leafmeal, MF = Maize flour, SBM = Soybean meal, FM = Fish meal, CLM = Cassava leafmeal, Nacl = Salt, Lys = Lysine, Meth = Methionine, Vit = Vitamin premix, Ca = Calcium power (bone meal), P.oil = Palm oil.

Equal rations of D₁, D₂, D₃ & D₄ were administered to the treatments at 5% body weight (FR) twice daily (06:00Hrs and 18:00Hrs). The ration was increased every 14 days as the body weight, (W) increased for the number of fish, N, in each replicate. Hence calculation for the feed Ration, Q was done using the formular

$$Q = \frac{N \cdot W \cdot FR}{100}$$

100 In grams per day.

The feed – trial experiment lasted for 22 weeks. Within this period culture water quality was properly managed through routine monitoring of temperature, pH, DO concentration and NH₃ (Ammonia) concentration to ensure they were within ambient condition. These were done with relevant test instruments. Both uneaten food particles and faecal matter were routinely siphoned out and culture water changed periodically.

The mean body weight of each Replicate was measured prior to stocking and at the end of the experimental period using a Digital Weighing Balance. At the end of the experimental period, the somatic (body) weight of 12 sub samples from each replicate as well as corresponding gonad (ovary or testes) weight was measured. This latter procedure was carried out after sacrificing the fish and exorcising the gonads. The ratio of the Gonad weight to the somatic weight gives the Gonado-Somatic Index (GSI) of the fish. This parameter was recorded for all the replicates and the mean calculated for the four treatments. Analysis of variance (ANOVA) was then used to make a test of significance between the treatments.

Results and Discussion

Results obtained in this study showed that the diet containing pawpaw leafmeal (PLM), D₃ recorded the least GSI value for both male and female fish. For male *C. gariepinus*, mean GSI was significantly highest ($P < 0.05$) in fish fed D₄ ($1.11 \pm 0.05\%$) followed by $1.09 \pm 0.13\%$ (D₁ – control), followed by $0.99 \pm 0.10\%$ (D₂) and least ($0.64 \pm 0.05\%$) in D₃. For female *C. gariepinus*, mean GSI was significantly highest ($P < 0.05$) in fish fed D₁ ($16.72 \pm 0.91\%$), followed by $11.16 \pm 0.40\%$ (D₄), followed by $9.88 \pm 0.73\%$ (D₂) and least ($6.68 \pm 0.52\%$) in D₃. These results are as shown on Table 2:

Table 2: Gonado Somatic Index (GSI) of male and female *C. gariepinus* fed four Experimental Diets.

Parameter	Male				Female			
	T ₁	T ₂	T ₃	T ₄	T ₁	T ₂	T ₃	T ₄
Mean W _s (g)	489.42 ± 29.82	435.00 ± 31.91	490.42 ± 43.10	424.00 ± 30.32	425.08 ± 21.80	453.75 ± 34.35	426.92 ± 37.92	412.33 ± 35.08
Mean W _G (g)	5.0± 0.33	4.08± 0.29	3.08± 0.31	4.67± 0.31	69.33 ± 2.50	42.58 ± 1.75	28.17 ± 3.00	44.92 ± 2.87
Mean GSI (%)	1.09± 0.13	0.99 ± 0.10	0.64± 0.05	1.11± 0.05	16.72 ± 0.91	9.88 ± 0.73	6.68 ± 0.52	11.16 ± 0.40

W_s = Somatic weight. W_G = Gonad weight. $GSI = \frac{W_G}{W_S} \times 100$

Correspondingly, fish fed a diet containing pawpaw leafmeal had the least gonad weights for both male fish ($3.08 \pm 0.31g$) and female ($28.17 \pm 3.00g$) while exhibiting high body weights – $490.42 \pm 43.10g$ and $426.92 \pm 37.92g$ for male and female respectively.

Research findings indicate that gonad development in cultured fish species has been found to be influenced by nutrition (Adewumi, 2005; Iquierdo et al; 2001; Ekanem and Ekanem, 2010; Sotolu and Kigbu, 2011; Ekanem et al; 2012; Asuquo et al, 2012; Ekanem et al; 2013; Eyo et al; 2014). While gonad development enhancement is desirable in brood stock for year round seed production, food fish where flesh is preferred to eggs rather require gonadal suppression. Feed composition in this case is the single most factor influencing gonadal development: 40% crude protein content in feeds enhanced gonadal development and in *C. gariepinus* spawning (Ibim and Sikoki; 2014) and the inclusion of ingredients with anti-fertility agents such as pawpaw leaves or seeds retard gonad development (Okwu and Okwu, 2004). Results obtained in this study showed that male and female fish fed diet containing pawpaw leafmeal had significantly ($p < 0.05$) lower mean GSI than the fish fed imported commercial feed (PODDER) and other formulated feeds with ingredients devoid of anti-fertility agents.

CONCLUSION

One of the major constraints to aquaculture is feed which can take up to 60 -70% of the overall cost of fish production (Gabriel et al, 2007; Davies et al, 2008; Jamabo & Alfred – Ockiya, 2008). This research has shown that using locally available raw materials such as leafmeals of cassava, pawpaw and banana incorporated with other conventional ingredients can reduce the cost of aquaculture production. The feeds formulated from these ingredients have been found to compete favourably with imported feeds such as PODDER from South Korea. Apart from contributing to the nutritional value of the feeds, pawpaw leafmeal has been found to suppress gonadal development while enhancing somatic (body) growth. This is a prerequisite to fish reared mostly for flesh consumption.

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Growth Performance and Feed Utilization of Nile Tilapia (*Oreochromis niloticus*) Fingerlings fed with Diets containing Baobab Leaf Meal

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Abstract

A multi-purpose tree: African Baobab (*Adansonia digitata*) leaf meal was evaluated as a dietary carbohydrate supplement in the production diet for Nile tilapia (*Oreochromis niloticus*) fingerlings with mean body weight 4.24 ± 0.04 g reared in plastic bowls. Four diets containing yellow maize meal carbohydrate at a rate of 25%, 50% and 75% along with the baobab leaf meal were formulated. The diet without the baobab leaf meal served as the control. The fish fingerlings were fed at 5% body weight per day for 42 days. It was revealed at the end of the experiment that baobab leaf meal was most suitable as a carbohydrate supplement when incorporated at 25% replacement. The body weight gain, specific growth rate and feed conversion ratio values of 56.07 g, 6.32 %/day and 1.88 respectively were highest in diet with 25% replacement closely followed by diet with 50% replacement. Beyond 75% inclusion level there was significant growth ($P > 0.05$). However, complete replacement of yellow maize meal by baobab leaf meal decreases growth rates and should not be used in *Oreochromis niloticus* diets.

Key words: Baobab leaf meal, Growth performance, Nile Tilapia.

Introduction

Aquaculture is an important source of human food and like all other agricultural and animal farming activities its productivity also totally depends on the provision and supply of nutrient inputs (Al-Asgah *et al.*, 2011). However, we need fish farming to meet increasing demands of food and nutrition values need for growing population which seafood best provides. It thus becomes increasingly important source of fish available for human consumption. As a result, it has become an important resource for human worldwide and in addition; it is one of the cheapest sources of animal protein which is easily digestible (Shalaby *et al.*, 2006).

African baobab (*Adansonia digitata* L.) is one of the eight species of baobab (*Adansonia*) and the only one native to mainland Africa (Ecocrop, 2011). Like other baobabs, the African baobab is a massive deciduous fruit tree, up to 20-30 m high, with a lifespan of several hundred years. Its swollen and often hollow trunk looks like a huge bottle and can be as broad as 3-7 m in diameter. It bears short, stout and tortuous branches and has a thin canopy (FAO, 2011).

Baobab is strongly anchored in the soil by an extensive and strong root system that grows 2 m deep, and whose diameter may be higher than the tree height. The leaves are simple or digitally compound, dark-green on top, and borne at the end of a 16 cm-long petiole. The leaflets are between 5-15 cm long and 1.5-7 cm broad. The baobab shed its leaves during the early dry season and new leaves appear after flowering. The pentamerous flowers are white, large (20 cm in diameter and 25 cm long), and hang from stalks on pedicels up to 90 cm long (Orwa *et al.*, 2009).

The fruit is a voluminous (35 cm long and 17 cm in diameter) ovoid capsule with a hard woody envelope containing a pulp and black seeds. Once ripe, the fruit envelope becomes brittle and the pulp takes on a chalky consistency. The tree starts producing fruits 8-10 years after planting but consistent production only occurs after 30 years (Bosch *et al.*, 2004; Jansen *et al.*, 1991).

Analysis of the chemicals constituents on a dry weight basis indicated that the Baobab leaves contained about 11% DM with a crude protein content of 5-17% (Feedipedia, 2013; Belewu *et al.*, 2007). Fibre variation is large, ranging from 10 to 19% DM (NDF 21-49% DM, ADF 16-41% DM and lignin 6-20 % DM) (Feedipedia, 2013). The leaves are rich in calcium (1 - 4% DM; Feedipedia, 2013) but it is questionable to what extent it is available to monogastric animals as they also contain gums which may impede absorption (Göhl, 1982).

Aqua feeds accounts for about 40 to 60% of the total cost of aquaculture operations. It is therefore necessary to look for non-traditional low cost feedstuffs to decrease the overall cost of fish production. The use of alternate feed resources for the development of aqua feed has therefore gained significance as the traditional ingredients are either becoming costly or less available (Hedge and Hofreiter, 1962).

Tilapia fish (*Oreochromis niloticus*) is a favourite delicacy in Nigeria (Ubalua and Ezeronye, 2007). It is important in aquaculture due to some good attributes like general hardiness, resistance to diseases, relatively fast growth, high tolerance to low water quality, high fecundity and its general acceptability by consumers.

The objective of this experiment was to determine the growth performance and nutrient utilization of *Oreochromis niloticus* fingerlings fed with diets containing baobab leaf meal in plastic bowls.

Materials and Methods

The experiment was carried out at the at the Feed mill Unit of Department of Fisheries Technology, Federal College of Freshwater Fisheries Technology, New Bussa, Niger State, Nigeria.

One hundred and fifty (150) fingerlings of *Oreochromis niloticus* of mean initial body weight of 4.24 ± 0.04 g was obtained from the Hatchery Unit, National Institute for freshwater Fisheries Research (NIFFR), New Bussa, Niger State and was used for the experiment.

The diets (about 35% crude protein) comprising the following feedstuffs: Baobab leaf meal, yellow maize meal, soyabean meal, groundnut cake meal, fish meal, vitamin premix, vegetable oil, methionine, lysine,

bone meal and salt were compounded at 0% (control diet), 25%, 50%, 75% and 100% as replacement for yellow maize meal.

Five diets (0, 25, 50, 75 and 100% inclusions of baobab leaf meal) corresponding to Diet 1, 2, 3, 4 and 5 replicated in three plastic bowl each) were fed at 5% body weight daily to *Oreochromis niloticus* fingerlings) (mean initial weight, 4.24±0.04 g) randomly stocked at 10 fingerlings per bowl (35-L capacity) for the period of 42 days.

The collected leaves were cleaned by washed properly with tap water. The baobab leaves were dried at room temperature before grinding. Thereafter, the baobab leaves were ground into fine powder using domestic grinding machine and analyzed for proximate composition according to standard method of AOAC (2015). After formulation, the ingredients were measured using electric sensitive weighing scale (OHAUS-LS-400 g Model). The ingredients were grounded and mixed properly by hand to have the desirable mixture that could be easily handled during diet preparation according to Royes and Chapman (2003).

The daily feed ration was divided into two equal portions, half of which was fed in the morning hours (between 07.00h and 08.00h) and the second half in the evening hours (17.00h and 18.00h). The pelleted diets were crushed into crumbs before administering them to the fish.

Fish sampling for growth was carried out weekly by scooping out all of the stocked fish per bowl. The fish samples for each replicate of each treatment were weighed using OHAUS 400 g balance (minimum weight – 1 g). At the end of the 42-day experiment, all the fish in each bowl were counted and weighed en masses to determine the survival (number) at the final weight.

The following parameters were calculated to determine the growth response of the fish to the diets as described by Obasa *et al*, (2013):

$$\text{Daily Weight Gain (DWG g/day)} = \frac{(\text{Final body weight} - \text{initial body weight})}{\text{Culture period (days)}}$$

$$\text{Specific Growth Rate (SGR) (\% per day)} = \frac{(\ln W_f - \ln W_i)}{\text{Time (days)}} \times 100$$

$$\text{Fed Conversion Ratio (FCR)} = \frac{\text{Weight of food given}}{\text{Fish weight gain (g)}}$$

$$\text{Survival Rate (\%)} = \frac{\text{Number of fish that survived}}{\text{Number of fish stocked}} \times 100$$

The data obtained from growth performance, chemical analysis and cost benefit analysis was subjected to statistical analysis using one-way analysis of variance (ANOVA), followed by Duncan's multiple range test for significant differences among treatments, Duncan, (1955). Analysis was performed using SPSS version II (Statistical Package for Social Sciences II). Significant level was chosen at $p < 0.05$. Values were expressed as means±SD.

Results and Discussion

The proximate composition of the baobab leaf meal is presented in Table 2. The proximate composition of the baobab leaf meal revealed that it contained (on dry matter basis) 8.00% moisture content, 9.51% crude protein, 3.47% crude fat, 9.38% crude fibre, 13.43% total ash and 56.21% nitrogen free extract (NFE). The gross energy value of the baobab leaf meal was 319.74 kcl/g while the metabolizable energy value of the baobab leaf meal was 294.11 kcl/g.

Table 2: Proximate composition of the Baobab leaf meal

Parameters	Baobab leaf meal
Moisture content	8.00
Crude protein	9.51
Crude fat	3.47

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Crude fibre	9.38
Total ash	13.43
NFE	56.21
Gross energy	319.74
Metabolizable energy	294.11

NFE (Nitrogen Free Extract) = 100 – (Crude protein + crude lipid + crude fibre + total ash). Gross energy = Caloric value of protein 5.65, lipid 9.45 carbohydrate 4.15 kcal/g (NRC, 1993); Metabolizable energy = Caloric value of protein 4.0, lipid 9.0 carbohydrate 4.0 kcal/g (Magdi, 2004).

The proximate composition of the experimental diets of *Oreochromis niloticus* fingerlings fed with diets containing baobab leaf is presented in Table 3. The result revealed that the diets were iso-nitrogenous. The protein content ranged from 35.01 to 35.02% and was not significantly different ($p>0.05$) and conforms to the recommendation of optimum dietary protein of fish (Adebayo, 2017).. The results also showed that there is a significant difference ($p>0.05$) in moisture, fat and carbohydrates of the different diets.

Table 3: Proximate composition of experimental diets containing baobab leaf meal

Proximate components	DT1 (0%BLM)	DT2 (25%BLM)	DT3 (50%BLM)	DT4 (75%BLM)	DT5 (100%BLM)
Moisture content	8.12	8.11	8.10	8.10	8.10
Crude protein (%)	35.01	35.02	35.02	35.01	35.02
Crude fat (%)	20.07	17.95	18.94	18.83	20.10
Crude fibre (%)	2.07	1.95	2.20	2.25	2.03
Total ash (%)	7.79	9.93	9.00	10.00	9.50
*NFE	28.10	28.22	27.92	27.09	26.48

Mean values are within rows with similar superscripts are not significantly different ($P>0.05$).

*NFE (Nitrogen Free Extract) = 100 – (Crude protein + crude lipid + crude fibre + total ash).

Table 4: Growth performance and feed utilization of *Oreochromis niloticus* fingerlings fed with diets containing baobab leaf meal for 42 days

Parameters	DT1 (0%BLM)	DT2 (25%BLM)	DT3 (50%BLM)	DT4 (75%BLM)	DT5 (100%BLM)
Mean initial weight (g)	4.24±0.05 ^a	4.23±0.05 ^a	4.23±0.06 ^a	4.23±0.05 ^a	4.24±0.05 ^a
Mean final weight (g)	67.70±1.59 ^a	60.30±0.44 ^b	58.03±0.85 ^c	52.63±0.29 ^d	50.70±0.6 ^e
Mean weight gain (g)	62.76±1.54 ^a	56.07±0.48 ^b	53.80±0.82 ^c	48.40±0.32 ^d	46.46±0.62 ^e
Daily growth rate (g/day)	1.49±0.04 ^a	1.34±0.01 ^b	1.28±0.02 ^c	1.15±0.01 ^d	1.10±0.01 ^e
Specific growth rate (%/day)	6.57±0.03 ^a	6.32±0.04 ^b	6.23±0.03 ^c	6.00±0.04 ^d	5.91±0.05 ^e
Feed intake (g)	106.00±0.10 ^a	105.60±0.15 ^b	105.58±0.15 ^b	105.44±0.02 ^b	105.44±0.2 ^b
Food conversion ratio (FCR)	1.69±0.04 ^e	1.88±0.02 ^d	1.96±0.03 ^c	2.18±0.01 ^c	2.27±0.03 ^a
Survival rate (%)	96.67±5.77 ^a	96.67±5.77 ^a	96.67±5.77 ^a	96.67±5.77 ^a	90.00±0.00 ^a
Total fish production (kg/m ³)	6.48±0.53 ^a	6.03±0.04 ^{ab}	5.61±0.39 ^{bc}	5.09±0.33 ^{cd}	4.56±0.06 ^d
Value of fish @ ₦1.00 per g	67.00±1.59 ^a	60.30±0.44 ^b	58.03±0.85 ^c	52.63±0.29 ^d	50.70±0.61 ^e
Cost of feed per g	63.03±0.06 ^a	58.90±0.14 ^b	55.15±0.73 ^c	52.29±0.66 ^d	49.87±0.65 ^e
Gross profit (GP)	3.97±1.53 ^a	1.40±0.44 ^{bc}	2.88±0.66 ^{ab}	0.34±0.38 ^c	0.83±1.07 ^c
Profit index (PI)	1.13±0.09 ^a	1.02±0.01 ^b	1.05±0.01 ^{ab}	1.01±0.01 ^b	1.04±0.02 ^b
Incidence of cost (IC)	0.94±0.03 ^c	0.98±0.01 ^{ab}	0.95±0.01 ^{bc}	1.00±0.01 ^a	0.98±0.02 ^{ab}
Net production value (g)	607.29±50.4 ^a	560.67±4.81 ^{ab}	520.26±36.27 ^{bc}	467.99±30.85 ^{cd}	418.14±5.61 ^d
Internal rate of revenue (RR)	1.20±0.06 ^a	1.05±0.01 ^{bc}	1.11±0.23 ^b	1.01±0.02 ^c	1.04±0.04 ^{bc}

Mean values in the same row with different superscripts are significantly different ($p<0.05$)

The significant difference ($P>0.05$) in the Growth performance and nutrient utilization of *Oreochromis niloticus* fingerlings fed with diets containing baobab leaf meal, showed that growth was affected by the inclusion of baobab leaf meal used to replace yellow maize meal at different inclusion levels. However, the

lack of significant difference between the control diets at 25% showed that maize meal could be supplemented at this level of inclusion in the diets of *O. niloticus* without compromising growth performance. This is in agreement to similar studies by Chumlong and Chutinthorn (2008) worked on the use of fermented feather meal for replacement of fish meal in the diet of *Oreochromis niloticus* and observed fermented feather meal could be used at 25% and up to 50% level in the diet of *Oreochromis niloticus* without compromising growth and feed utilization efficiency and resulted in a decrease in weight gain and associated growth parameters with high increasing replacement. On the other hand, Ayotunde *et al.*, (2016) worked on effect of partial replacement of fish meal with *Moringa oleifera* leaf meal on the haematology, carcass composition and growth performance of *Clarias gariepinus* (Burchell 1822) fingerlings. They observed that up to 30% inclusion level of *Moringa oleifera* leaf meal could be included in the diets *Clarias gariepinus* fingerlings without affecting growth and feed utilization.

Also, Fasakin and Balogun (2001) studied the use of water fern (*Azolla pinnata*) Evaluation of dried water fern (*Azolla pinnata*) as a replacer for soyabean dietary component for *Clarias gariepinus* fingerlings and observed that up to 25% content could be used as a complete replacement for commercial feed in diet formulation for *Clarias gariepinus* fingerlings. Bichi and Ahmed, (2010) also studied the growth performance and nutrient utilization of African catfish (*Clarias gariepinus*) fed varying dietary levels of processed cassava leaves. The results showed that there was significant difference ($P < 0.05$) between fish fed control diets and processed cassava leaves meal-based diets at 10% inclusion levels. Fagbenro, *et al.*, (2010) also studied the potential nutritive value of raw sunflower and sesame seed meal as dietary replacement of soybean meal in practical diets of *Clarias gariepinus*. The results showed that there was significant difference ($P < 0.05$) between fish fed control diets and raw sunflower and sesame seed meal- based diets at 45% inclusion levels. Adikwu (2003) coconut cake (*Cocos nucifera*) worked also on nutritional evaluation of Coconut cake (*Cocos nucifera*) as dietary protein source for *Oreochromis niloticus*. The results of this study showed that inclusion of coconut cake (*Cocos nucifera*) was successful on the growth performance and feed utilization in tilapia.

Conclusion

This study has shown that 25% baobab leaf meal can serve as a substitute for yellow maize meal in the diet for Nile tilapia, *Oreochromis niloticus* fingerlings without compromising growth.

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Prevalence of Ectoparasite and Endoparasite of *Clarias gariepinus* from River Ibi, Taraba State, Nigeria

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Abstract

Prevalence of ectoparasites and endoparasites in *Clarias gariepinus* was carried out from January, 2022 to March, 2022 in River Ibi, Taraba State, Nigeria. A total of thirty-five (35) fishes (*Clarias gariepinus*) were purchased from artisanal fisher folks at Nwonyo fish-landing site. Identification and examination were conducted in the laboratory for ectoparasite; the skin was scrapped and a piece was cut and mixed with 3ml of 0.9% saline solution before observation with a hand lens. The endoparasites were observed by dissecting

the fishes using scalpel blade, and a portion of stomach content was collected and diluted with small amount of saline solution, placed under slide and observed under microscope at $\times 10$ magnification. Highest prevalence rate of 38.46% was observed on the skin of infected females than males. *Ichthyophthirus multifilis* found on the gills of infected female has the highest prevalence rate of 27.27% for ectoparasites and *Cryptobia iubilans* with highest prevalence rate of 28.57% on the intestine of infected females. A coefficient of regression statistically identified on the samples reveals that the length-weight linear relationship is correlated such that the length is a determinant factor for weight of *Clarias gariepinus* species. Maximum R^2 value 0.8694 for infected males and R^2 value 0.033 for infected female samples. The condition factor also shows that female fish examined are more adapted to their environment compared to males. It is therefore recommended that fish farmers and sellers should be enlightened on the potential risk of parasitic infection of fishes in order to avoid economic loss

Keywords: Prevalence, Ectoparasites, Endoparasites, *Clarias gariepinus*, River Ibi.

Introduction

Fish are highly recommended because of their essential fatty acids, high economic value and essential nutrition for the human body (Amos *et al.*, 2021). A parasite can be referred to as an organism that lives in or on another animal (Host) at the expense of the animal. Bassey (2011) reported that parasites are the most diverse and common disease of fish. In recent time, medically important parasite presents in fishes have been source of concern to both medical practitioners and veterinarians. Parasitic infections are some of the factors hindering high fish productivity in fish farming (Dovellou, 2012). Parasites are one of the most diverse and common pathogens the aquaculturist may likely encounter as parasitic disease are very common all over the world and are of particular importance in the tropics (Onyedineke *et al.*, 2010). The parasitic infection of fish gives an indication of the quality of water, as they generally increase the abundance and diversity in more polluted water irrespective of the species either through injury on the tissue organs in the process of burrowing or consuming food or the removal of digested food in the gut of the fish as well as the secretion of proteolytic enzymes (Udechukwu C.U *et al.*, 2018). *C. gariepinus* has been plagued by various parasites in the wild and cultured environment where they cause morbidity, mortality and economic losses in aquaculture practice in various parts of the world (Kawe *et al.*, 2016 and Biu *et al.*, 2014). Various helminth parasites have been incriminated in *C. gariepinus* infection such as adult Digenea infecting different tissues of the body; trematode cercaria of the family *Clinostomidae* encysting in tissues; and adult monogeneans of the families *Pousopothocetylidae*, *Dactylogyridae* and *Gyrodactylidae* infecting the gills and skin, Cletus and Raymond (2016). Trematodes are among the major parasites found affecting *C. gariepinus*, it damages the muscles of fish making it disgusting and unmarketable. In human flatworm causes a condition called *Trematodosis*. Fish roundworms (Nematodes) causes a condition in human called *Anisikiasis*. Fish tapeworms (cestodes) causes a condition in human called *Diphyllobothriasis*. *Clarias gariepinus* has shown high parasitemia of both medical and economic concern, its high level of endoparasite and ectoparasite may result in adverse conditions either to the aquatic system or to animals (human inclusive) who consumed this species of fish (Odoh V.U *et al.*, 2019). The aim of the study is to determine the prevalence of ectoparasites and endoparasites on *Clarias gariepinus* from River Ibi, Taraba State with these objectives: 1. To identify and determine the rate of prevalence of ectoparasites and endoparasites infection of *Clarias gariepinus* from River Ibi. 2. To determine the condition factor of *Clarias gariepinus* from River Ibi. The rate of occurrence and widespread of ectoparasite and endoparasite in *Clarias gariepinus* in River Ibi, causing morbidity amongst these species and destroying some tissues in them. As a result, this study was carried out to check the prevalence of some of the ectoparasite and endoparasite in the study area.

Materials and Methods

Study area

Ibi local Government Taraba State, Nigeria is located at the South bank of the Benue River opposite the influx of the much smaller Shemanker river. It lies on Latitude $8^{\circ} 10' 52.39''$ N and Longitude $9^{\circ} 44' 39.52''$ E. it has an estimated population of about 22,757. The river Ibi is one of the main rivers in the state alongside River Benue, Donga, and Taraba. The major occupation of people in Ibi Local Government Area is fishing activities.

Collection of Sample

Clarias gariepinus were purchased alive from the artisanal fisher folks at a fish-landing site along River Ibi between January 2022 and March 2022. The fishes were placed in a water-filled plastic container and taken to the biology laboratory of Federal University Wukari for parasitic examination. A total of 35 fishes were examined.

Length and Weight Measurement of Fish

The total and standard lengths of the fish was measured to the nearest centimeter using a meter rule. The total length was taken from the tip of the snout to the extreme end of the caudal fin and the standard length from the tip of the snout to the end of the caudal peduncle. The total weight was taken to the nearest gram using a weighing balance.

Sex Determination

Males are characterized by the presence of a papilla situated roughly between the pelvic fins; this structure is absent in females. To be certain, two testes was identified in males when the abdomen was slit open, and two ovaries was identified in the case of females.

Parasitological Technique for Examination of Ectoparasites and Endoparasites

External examination (Ectoparasite) of each of the fish for parasite was carried out using technique of Emere and Egbe (2006) on the skin and gills. The skin and gills were examined for ectoparasite using hand lens. The fish samples, *C.gariepinus* were taken to the laboratory. For the fish, the skin was scrapped out and a portion was cut using scalpel blade, to be used as a sample for ectoparasite examination. The skin was placed on a Petri dish, and 3ml of 0.9% saline solution was added and then stirred the mixture using glass rod. Some drips of mixed solution were collected using dropper, placed on a slide and covered with a cover slip after which observation was made on light microscope. The gills of each of the fish was dissected using a dissecting kit. Each of the gills were placed in 10ml of normal saline into the Petri dish and later removed and then placed on a slide on which 1-2 drops of saline was added and observed on a light microscope. The endoparasites were examined by cutting from the rectum to the esophagus and opening the gastrointestinal tract of individual fish using standard parasitological methods as described by Paperna, (1996), the intestine was cut at the tip and little quantity of the stomach content was collected and diluted with small amount of normal saline on a wash glass. The content was later placed on the slide covered with cover slip for examination and identification under light microscope at x 10.

Statistical Analysis

Statistical package for social sciences (SPSS) version 23 was used for statistical analysis. Chi-square was used to test the significance of the condition factor of *Clarias* species at 0.05 confidence interval. Prevalence of intestinal parasites of fish samples were calculated according to Tombi and Bilong, (2004). Prevalence rate (100%) = $\frac{\text{number of infected samples}}{\text{Total number of samles}} \times 100$

Results and Discussion

Table 1 below Shows the different types of ectoparasites found on the gills and skin of *Clarias gariepinus* and their corresponding prevalence rates based on their sexes. Thirteen (13) infected males with most prevalence rate of 30.77% and 11 infected females with most prevalence rate of 27.27% were identified on the gills. While 15 infected males with most prevalence rate of 20.0% and 5 infected females with 38.46% prevalence rate were also identified on infected females, this was observed to be the highest prevalence rate for ectoparasites found on the gills and skin of infected *Clarias gariepinus*. The parasites identified were *microsporidian*, *piscinoodium*, *epistylis* and *cryptocaryon* etc

Table 1: Identified Ectoparasites of *Clarias gariepinus*

Parasite	Gill				Skin			
	Male	%	Female	%	Male	%	Female	%
Microsporidians	2	15.38	2	18.18	2	13.33	-	-

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Piscinoodium	2	15.38	1	9.09	3	20.0	1	7.69
Coccidia	4	30.77	3	27.27	1	6.67	1	7.69
Ichthyophthirius	1	7.69	3	27.27	-	-	5	38.46
Dactylogryus	1	7.69	-	-	1	6.67	-	-
Capiniana	1	7.69	-	-	-	-	-	-
Tetrahymena	-	-	1	9.09	-	-	2	15.38
Hexamita	-	-	1	9.09	1	6.67	1	7.69
Myxozoa	2	15.38	-	-	1	6.67	-	-
Epistylis	-	-	-	-	1	6.67	1	7.69
Cryptocaryon	-	-	-	-	1	6.67	-	-
Garyodactylus	-	-	-	-	1	6.67	1	7.69
Apiosoma	-	-	-	-	1	6.67	-	-
Camallanus	-	-	-	-	2	13.33	1	7.69

Table 2 shows the different types of intestinal parasites identified in *Clarias gariepinus*. A total of twelve (12) males were infected, three (3) male samples were infected with *tetrahymena* parasites with prevalent rate of 25.00%. While a total number of 14 females were also infected. Four (4) female samples were infected with *Cryptobia iubilance* having the most prevalent rate of 28.57% which also occur to be the highest prevalent rate of endoparasites.

Table 2: Identified Endoparasites of *Clarias gariepinus*

Parasite	Male	%	Female	%
Tetrahymena	3	25.00	2	14.29
Degenean	2	16.67	-	-
Hexamita	2	16.67	2	14.29
Nematodes	1	08.33	1	07.14
Eustroglides	1	08.33	2	14.29
Microsporidians	1	08.33	1	07.14
Cryptobiansiubilans	1	08.33	2	14.29
Coccidia	1	8.33	2	14.29

Table 3 reveals that the highest prevalence rates for ectoparasites was observed to be 42.86% in a number of 15 infected male *Clarias gariepinus*. Whereas the most prevalence rate endoparasites (intestine) were observed in 14 infected females to be 40.00%.

Table 3: Prevalence rate of ectoparasites and endoparasites of *Clarias gariepinus*

Sex/Site	Total No. Examined	No. Infected	Prevalence Rate (%)
Ectoparasites: Gills			
Male	17	13	37.14
Female	18	11	31.14
Ectoparasites: Skin			
Male	17	15	42.86
Female	18	13	37.14
Endoparasite: Intestine			
Male	17	12	34.29
Female	18	14	40.00

Table 4 shows that the coefficient of regression (R^2) is highest in male R^2 value 0.8694 and the overall lowest regression in female having R^2 value 0.033. This explains length-weight linear relationship and dependency. The condition factor reveals that female species k value (gill: 0.7040, skin: 0.7090 and intestine: -0.0926) were in better condition than the male.

Table 4: Condition factor and Parameters estimated from length-weight linear relationship

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Sex/Site	Log a	b	R	K
Infected Gills				
Male	-3.0138	3.6184	0.8694	0.6919
Female	-3.4937	4.0078	0.7906	0.7040
Infected Skin				
Male	1.5576	0.1740	0.0393	0.6946
Female	-3.2746	3.8303	0.7409	0.7090
Infected Intestine				
Male	-3.0154	2.1446	0.5337	-0.0977
Female	-0.8821	0.9352	0.0333	-0.0926

Based on their sexes, 13 and 15 males were infected on the gills and skin while 11 and 13 females were also infected on the same tissue organs. The result also revealed that 13 infected males with prevalent rate of 37.14% parasite found on the gills than in 11 numbers of females with 31.14% prevalent rate. This disagrees with the report of Amos *et al.*, (2021) and Ibiwoye *et al.*, (2004) who reported more parasite infection in female fishes than their male counterpart. The result showed 15 males having highest prevalent rate of 42.86% infection on the skin than females with prevalent rate of 37.14%. The result agrees with Danba *et al.*, (2019) who reported a high infection rate of ectoparasites on male than female fishes obtained from Kasuwan Bera and Mayo-Gwoi of Ardo kola and Jalingo LGAs of Taraba State, Nigeria. This can simply be accounted for by the fact that males are not stable in one place but use to migrate in search of foods and sex, this then makes them susceptible and exposed to parasitic infestation. In contrast, the female highest infection by endoparasites is attributed to spawning during eggs laying which can allow parasitic infestation inward or inside the female body. The ectoparasites identified were *mircosporidians*, *piscinoodium*, *dactylogyrus* etc with their corresponding prevalent rates. According to the results obtained 12 males and 14 females were also infected in the intestine of the fish samples. The endoparasites identified include; *tetrahymena*, *degeneans*, *hexamita* and *nematodes* etc with their individual prevalence rate. This finding is in contrast with Kizito and Adams, (2014) who reported endoparasites identified were *Cappilaria* and *Trichodina* in their study area in river Hadejia.

Variations in parasitic infection among the sexes of fish studied were not significant implying that higher infection rates in either the male or female were simply by chance. This however contradicts Emere (2000), who reported differences in the incidence of infestation between male and female fish, which may be due to differential feeding either by quantity or quality of feed, or as a result of different degrees of resistance to infection. This study reported higher infection in male than female *Clarias gariepinus* which contradicts a study done by Emere and Egbe (2006), reported higher parasitic infection in females than males. Based on this study, this is due to the instability of males migrating from one place to another in search of food and sex which made them susceptible or exposed to certain parasitic infection. The presence of helminth parasitic infection in this study is enough to cause some pathological effect in fishes by reducing their growth, development and even the market value. Fish parasitism constitutes a major threat to fish productivity and the increased demand on fish as a ready and safe source of protein to humans.

Condition factor (K) describes the health and the general well-being of fish in its environment. The maximum condition factor for infected male *Clarias gariepinus* 0.6919 was less than that of the infected female 0.7090 *Clarias gariepinus*. It shows that female *Clarias gariepinus* are in a good condition compared to the male *Clarias gariepinus* in the habitat. This implies that the non-infected *Clarias gariepinus* seems to be in a better state of wellbeing than infected ones. The slope value 'b' describes the growth pattern of fish. The maximum b value of 2.1446 for infected male intestine was recorded for *Clarias gariepinus*. This indicates negative allometric growth pattern. But b value is maximum in female at 4.0078 which means positive allometric growth for the female *Clarias gariepinus*. This is because, when b value is less than three (< 3) it is a negative allometric growth pattern in fish, but when b is greater than three (> 3) the allometric growth pattern is positive. This might be due to contamination of the river by dumping domestic waste, disposing of sewage into the river. Increased inorganic matter in water may also be a factor that affects the growth pattern of fish which agrees with the report of Edema *et al.*, (2008).

The fish has contributed to the development of biodiversity of the river on the bases of their infestation resistivity and tolerance. Hence, it is recommended that fish farmers and sellers should be enlightened on

the potential risk of parasitic infection of fishes in order to avoid economic loss and more details study is also recommended in order to further establish the parasites fauna of fish species from River Ibi.

Conclusion

The study revealed that *Clarias gariepinus* in River Ibi Taraba State harbors various types of ectoparasites and endoparasites, some of which are highly pathogenic to fish species. *Ichthyopterygius multifilis* are the most prevalence ectoparasites found on the gills of infected females while *Cryptobia iubilans* found in the intestine was the most prevalent endoparasites.

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Simulation-Driven Product Development (SDPD): A Panacea to Technology Product Delivery in Fisheries and Aquaculture Production in Nigeria

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Abstract

This article gives an overview of the potentials of fisheries and aquaculture in Nigeria and identified that product development at present in this subsector relies solely on the traditional method of build-and-test in one-factor-at-a-time testing which is completely arbitrary, expensive and time consuming. This approach is not effective for technology product delivery in comparison with the growth of fisheries and aquaculture in the country. It also identified value chain analysis as the possible source of product development (new or existing). Computer aided engineering (CAE) toolchains in systems engineering methodology for simulation-driven products development in fisheries and aquaculture were further identified and their applications specified. Computer integrated technology (simulation-driven product design and development) in the few areas it has been used in fisheries and aquaculture in Nigeria has been found to be of profitability benefits. These include its capability to economically ascertain the effect of different system and process parameters on the outcome of the processes, minimizes the number of experiments that need to be performed to determine the influence of various parameters on the safety and quality of the process and permit parametric analysis to understand the effect of different parameters in the systems. It has also enabled effective and efficient digitization, automation and optimization of fisheries and aquaculture processes and systems.

Keywords: Computer-aided engineering, Fisheries and aquaculture, Product design and development, Simulation modelling, Technology

Introduction

Fisheries and aquaculture are not just the source of health but also of wealth. Nigeria's fisheries and aquaculture is one of the fastest growing subsectors of agricultural sector of the economy with total fisheries production estimated at 102700 tonnes and contributed 0.5 percent of national gross domestic product (GDP) in 2015 (FAO, 2017). Nigeria is the largest aquaculture producer in Sub-Saharan Africa with a steady increase in production from 21700 tonnes in 1999 to 316700 tonnes in 2015. Technology in different forms (procedures, know-how, or equipment) is embodied in every value activity in a firm or industry. Consequently, change in technology can affect competitive advantage if it has an important role in determining comparative cost position or differentiation (Porter, 1985 and PDMA, 2013). Such change in technology in fisheries and aquaculture results in new products or improvement on existing products. Analysis of the fisheries and aquaculture value chain, (Sule *et al.*, 2021; Madu, 2016; Omojowo *et al.*, 2015; USAID, 2012 and Hempel, 2010) revealed the potentials in technology product development (particularly new/existing products that are engineered, discrete, and physical) in the fisheries and aquaculture sub-sector of agricultural sector as shown in Figure 1.

However, technology product delivery is no commensurate with the growth in fisheries and aquaculture in Nigeria. Product development is the set of activities beginning with the perception of a market opportunity

and ending in the production, sale, and delivery of a product (Ulrich and Eppinger, 2015). Product design and development is therefore the integration of the marketing, design, and manufacturing functions of the firm in creating a new product or improving on existing product. A successful product development results in products that can be produced and sold profitably with profitability defined in terms of more specific dimensions of product quality, product cost, development time, development cost and development capability all assessed by the performance of a product development effort.

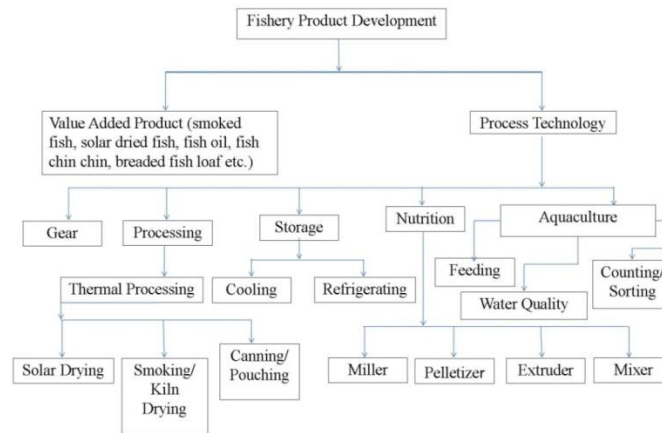


Figure 1: Process Technologies in Fisheries and Aquaculture Value Chain

Traditional Product Development Process

The traditional product development process shown in Figure 2 requires asking and proffering solutions to numerous questions. The traditional product development process in fisheries and aquaculture performed a sequence of steps that transforms a set of inputs into a set of output which is tested through experimentation.

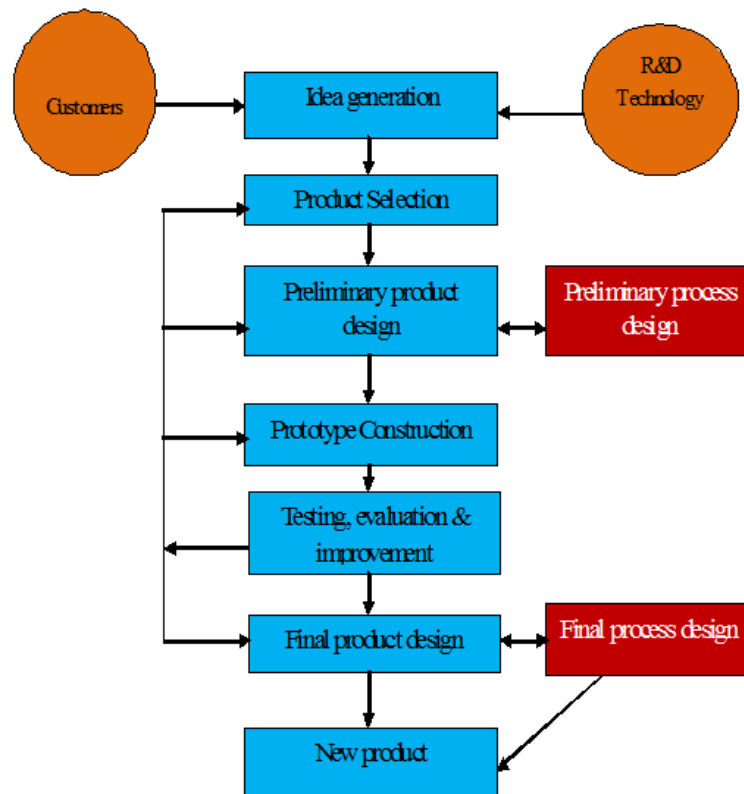


Figure 3: Traditional Product Development Process

This is obvious in the numerous attempts at improving the smoking kiln which is one of the dryers in fish processing as well as other engineered products and processes in the sector.

Materials and Methods

Simulation-driven product development is hinged on system integration approach in systems engineering methodology (BKCASE Editorial Board, 2015 and Muller, 2013). Table 1 presents the computer aided engineering infrastructures applied in simulation-driven products development in fisheries and aquaculture.

Table 2: Computer Aided Engineering (CAE) Tools Applications in Fisheries and Aquaculture

S/NO.	CAE TOOLCHAIN	APPLICATIONS IN FISHERIES AND AQUACULTURE
1.	ANSYS 10 and 14	Energy and Thermo-fluid systems design
2.	Proteus design suits	Embedded system design/Automation
3.	Intel Quartus	Embedded machine vision design/Automation
4	Xilinx	Embedded machine vision design/Automation

Simulation Product Development in Fisheries and Aquaculture

The product development process (see Figure 2) is an iterative complex process that requires a system approach for its profitability solution and simulation product development delivers such approach. Besides, Industry 4.0 (the fourth industrial revolution) characterized by the integration of the digital, biological, and physical worlds, as well as the growing utilization of new technologies such as Industrial Internet of Things (IIoT), artificial intelligence (AI), cloud computing and advanced wireless technologies, among others has ushered in a new era of economic disruption with uncertain socio-economic consequences for Africa and particularly, Nigeria (Ndung'u, and Signé, 2020; Bonneau *et al.*, 2017; Hwang and Chen, 2017 and Gilchrist, 2016). Build-and-test as a method for innovative design decision in the exploration of design alternatives particularly for embedded system is expensive and time consuming considering the cost of those components (microcontrollers and integrated circuit) that are highly susceptible to damage making simulation product development inevitable. Simulation modelling is the process of creating and experimenting with a computerized mathematical model of a physical system. Simulations are invaluable to validate a proposed design. Computer-aided engineering (CAE) analysis as a product design and development philosophy combines three key engineering elements in an integrated environment for all engineering functions within each stage of the product development cycle. These elements are: applications (performance, structural integrity, reliability and costs), facilities (hardware/software), and technology (data and information management). The CAE analysis approach to product development emphasizes system analytical modelling and analysis techniques at the earliest phase of design, that is, conceptual design. The analysis approach begins with simulation modelling of products and manufacturing (an integrated set of total system simulations of the entire product). Simulation modelling most often originates from system dynamics which is the mathematical modelling of a dynamic system in order to understand the behaviour of the system and predict system performance (Okouzi, 2019). Each alternative product concept is mathematically modelled as an entire system. At this point, overall product designers have the flexibility of defining significantly varying concepts in order to automate or optimize (minimize or maximize) performance for acceptable product concepts (Ulrich and Eppinger, 2015; DOD, 2001 and Bullinger, *et al.*, 2001a). The technique of simulation has long been an essential tool of the designer and the purpose is to investigate and compare various proposed system configurations to help choose the best one (Ulrich and Eppinger, 2015; Hillier and Lieberman, 2001 and Bullinger, *et al.*, 2001). The design of complex systems often involves making decisions in advance of the final process and product being created and so the designer is often not totally sure of the consequences of these decisions. It is therefore a proper engineering practice to simulate how the process might work so as to increase confidence in design decision. Hence, simulation is one of the most fundamental approaches to evidence-based decision making (that is, based on the analysis and evaluation of data and information) (Ulrich and Eppinger, 2015; ISO 9000:2015; DOD, 2001; and Huang and Nof, 2001). In Nigeria, simulation product development has been applied in developing fisheries and aquaculture technology in few circumstances. Outdoor concrete ponds are normally subjected to thermal effect from solar radiation. This thermal effect is capable of causing deterioration in the concrete fish ponds especially in arid regions. This stochastic process has been studied by the numerical simulation of thermal diffusion in outdoor concrete fish pond as presented in Figure 4 (Eze *et al.*, 2016).

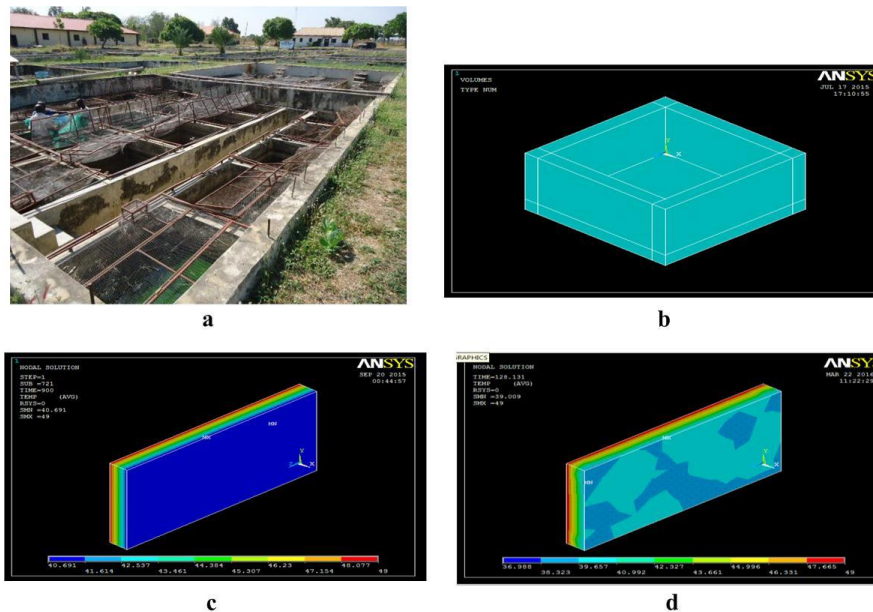


Figure 5: Simulation of Thermal Diffusion in Walls of Concrete Fish Pond [Eze *et al.*, 2016]

As product designs become more complex, the need for high-performance computing (HPC) becomes increasingly essential. Simulation modelling has enabled the study of the cross-disciplinary and multidisciplinary process of drying in NIFFR solar tent dryer presented in Figure 6 (Okouzi, 2020). This process automation study further made the optimization of the batch process in the rectangular passive greenhouse dryer possible (Okouzi, 2021).

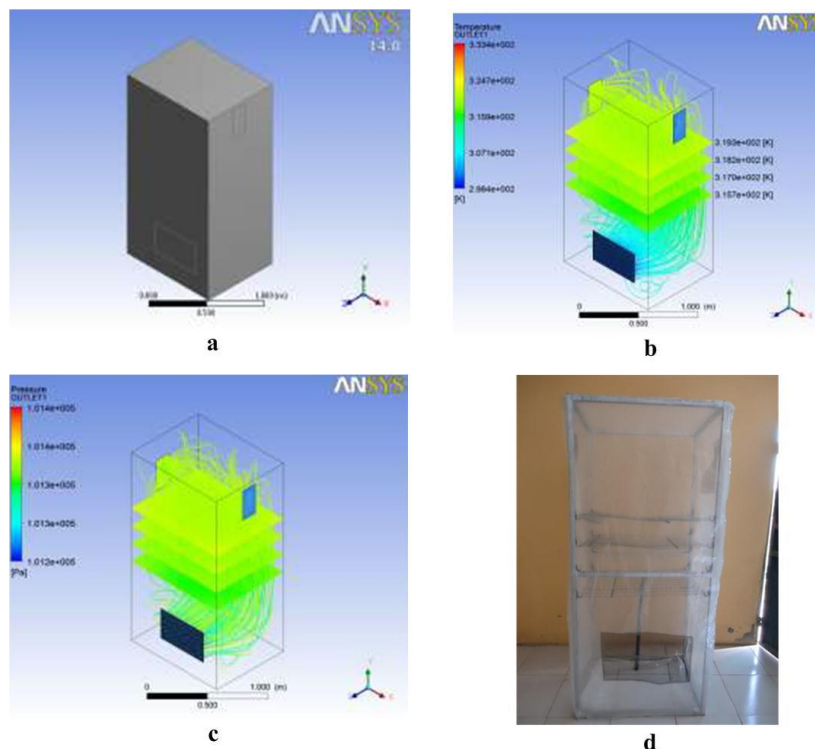


Figure 7: CFD Simulation of the Batch Process in Rectangular Passive Greenhouse Dryer (Okouzi *et al.*, 2020)

The computational fluids dynamic (CFD) engineering integrated into the product development process generated better results overall. The CFD engineering simulation technology enabled efficient evaluation of alternative ideals at an early state consequently, discovering new paths for the design to optimally meet specifications such as performance, reliability and sustainability. Simulation modelling is an inevitable tool in the automation of systems. Consequently, the indigenous Boat-operated Atalla lift net for capturing of

Clupeids (Freshwater Sardine) has also been upgraded within a period of 18 months using virtual system modelling (VSM) simulation in Proteus design suits. This study involved VSM simulation, automation and robotic integration which ordinarily cannot be economically undertaken by built-and-test approach.

Conclusion

The quick adoption of simulation driven product development may sooner be the deciding factor between industries that stay ahead in the competition and those that fall behind. Simulation modelling has been sparsely used as a product development tool in fisheries and aquaculture in Nigeria as revealed by this study. However, in situation where it has been used, it has been found to provide understanding of the details of the physical phenomena, and are hence of great importance for the designers. It results have been obtained much faster than prototype building and testing. A great strength of simulation lies in the ability to perform parametric studies that replace expensive trial-and-error loops in classical design processes. There has also been the possibility of analysing systems under conditions that are difficult to create experimentally. Simulation product development has enabled the automation and optimization of some fisheries and aquaculture technologies. Hence, simulation product development is a panacea and a viable too for technology product delivery in fisheries and aquaculture production in Nigeria.

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Socio-economic and constraints of unemployed youth and women participating in fish farming entrepreneurial training in Maiduguri, Borno State

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ABSTRACT

This research was conducted to study the Socioeconomics characteristics of Entrepreneurial training of unemployed youth and women in fish farming examine. A sample of (100) respondents were selected for the study to generate both primary and secondary data which were analyzed using descriptive statistical. The results of the study revealed that majority of respondents 54.40% are females while 45.60% are males. The majority of the respondent are within the age bracket of 31-40, 38.20% while the less percentage are within the age bracket of 41 and above 14.70%. The 39.70% of the respondents attended tertiary institution and 1.50% of respondents attend Non formal education. the majority of respondents are unemployed which is 54.40% a while 20.60% of respondents are engages in business activities; This shows that majority of the respondents are married which 60.30% and less is 2.90% of respondents are divorcee.

Key words: Entrepreneurship, Fish farming, Unemployed , Youth, Women

INTRODUCTION

Nigerians are large consumers of fish and it remains one of the main products consumed in terms of animal protein. Only about 50% of demand for fish is currently being met by local supply. Belhabib *et al.* (2015) reported that the fisheries sector contributes 3.5% of Nigeria's growth domestic product (GDP) and provides direct and indirect employment to over six million people. Besides, Nigeria has many rivers and water bodies which serve as good locations to set-up fish farms. Nutritionally, fish is preferred to other kinds of meat and this is evident in the ever-increasing demand for it. The benefits accruing from fish thus, necessitate its production.

Entrepreneurship according to Agomuo (2002) is a process of bringing together creative and innovative ideas, combining them with management and organization skills in order to combine people, money, and resources to meet an identified need. In the view of Okeme *et al.*, (2014) entrepreneurship is the process through which individuals combine human and material resources in order to provide goods and

services desired by man. Entrepreneurship in fish production with a myriad of activities cannot be effectively pursued without requisite skills

The roles played by youth and women in meeting the challenges of agricultural production and development are quite prominent and this cannot be trivialized. Findings from a study by the United Nations Development Programme (UNDP) revealed that youths and women make up some 60-80 percent of agricultural labour force in Nigeria (World Bank, 2003). Depending on the region, they produce two thirds of the food crops. Sadly, female farmers in the country are among the voiceless, especially with respect to influencing agricultural policies. Such policies, which are aimed at increasing food production and food security, tend to under estimate and totally ignore women's role in both production and the general decision-making process within the household.

One of the greatest social problems facing Nigeria since the re-commencement of democratic rule on 29 May, 1999 is the menace of youth insurgency. This situation is a state of insecurity that exists in an environment arising from individuals or groups that have a feeling of dissatisfaction, marginalization or inequality. The return to democracy in Nigeria brought hopes of rapid development and political stability but the last decade has experienced an upsurge in violent conflicts and criminality, which tended to undermine those expectations. The violence and criminality have come in the form of armed robbery, kidnapping, bombing, ethno-religious militancy, intra and inter party clashes, murder, hostage taking, rape, riot, cultism, vandalism, arson, drug trafficking, arms smuggling, human trafficking among others which have significantly undermined the internal security and economic development of the nation. The role of youths in Nigerian generally as critical actors in insurgency does not guarantee peace and national development hence, the need to adequately engage them in viable alternative ventures (Eyo, 2000).

Study Area

Maiduguri is located between latitudes $11^{\circ} 42' N$ and $12^{\circ} 00' N$ and longitudes 12.54 and $13^{\circ} 14' E$. Maiduguri covered an area of 543km^2 . The city is bounded in the north by Jere LGA, in the west, south and south-west by Konduga LGA, in the north-west by Mafa LGA. Maiduguri has mean annual maximum temperature of 34.8 with mean temperature ranging between 30°C and 40°C . The months of March and April are usually the hottest months, while November and January are the cold and dry periods of harmattan. The city receives rainfall from June to September. However, in rainy years, the city records rainfall earlier than June and later than September. Being a nodal city, trading is the major occupation of the inhabitants with few agrarian practices. The city is situated in a plain area. One of the problems confronting the geography of Maiduguri urban is the non-availability of a standard boundary of the urban. Therefore, in this study, the urban is defined to be the areas between latitudes $11^{\circ} 27' 30'' N$ and $11^{\circ} 33' 30'' N$ and longitudes $13^{\circ} 2' 30'' E$ and $13^{\circ} 9' 10'' E$.

The primary and secondary data were collected through direct interviews, personal observations and responses of the respondents to questionnaires administered in some selected streets around Maiduguri Metropolis in Borno State and interview was conducted with an agent of a private waste management in the study area.

The research design that was adopted in this study is the social-science design under which the survey design techniques was adopted. Interview were conducted for the youths and women and also questionnaires were administered to the general community in the selected locations in the study area.

Population of one hundred (100) respondents were selected, and one hundred (100) questionnaires were administered to have a representation of the various groups of respondents in the study area. The first stage in the collection of primary data involved the reconnaissance survey of the study area, to enhance familiarization and also facilitates the easy administration of questionnaire. The second stage involves oral interview with both youths and women in the study area. As a result of the homogeneity of the target population these samples size were given a well representation of the sample frame.

In this research, random sampling techniques were used due to the largeness of the frame of the study area.

Methods of Data Analysis

Proceedings of the 37th Annual Conference of FISON

Analysis of data for this study was done considering the different objectives that were used to achieve this study which included the questionnaire and other primary data. Each of these data set was processed and analyzed separately based on each objective of the research. Where descriptive frequency was used.

RESULTS AND DISCUSSION

Table 1:Socio-economic Characteristics of the Respondents

Socio-economic	Frequency	Percentage
Age		
<20	14	20.6%
20-30	18	26.5%
31-40	26	38.2%
41 and above	10	14.7%
Gender		
Male	31	45.6%
Female	37	54.4%
Marital status		
Single	22	32.4%
Married	41	60.3%
Divorced	2	2.9%
Widow	3	4.4%
Family size		
1—4	35	51.5%
5—9	18	26.5%
10—15	12	17.6%
16-20	3	4.4%
above 20	0	0.0%
Educational background		
Non-formal	1	1.5%
Quaranic education	11	16.2%
Primary education	4	5.9%
Adult education	4	5.9%
Second education	21	30.9%
Tertiary education	27	39.7%
Occupation		
Civil servant	17	25.0%
Business man	14	20.6%
Unemployed	37	54.4%

Source: Field Survey, 2021

The results of the study revealed that majority of respondents 54.40% are females and 45.60% are males this shows that women had a higher number of participant than male, the training programmed was empowered women so as to become self-employed and also gender does not prevent women from participation in training exercise. Age the majority of the respondent are within the age bracket of 31-40 has the highest percentage of 38.20% while the least percentage had 14.70% at the age of 41 and above, this indicated that age have important role to play in training participation youth are very active and willing to learn in the training activities and willing to do whatever ask to do during the training programmed, while less percentage are due to the old agensis and other factors associated with age. Education also has vital role to play toward youth and women participation in training programmed it can serve and guide and directing ones toward achieving his/her goals and objectives in life time this indicated that the majority of the respondents 39.70% attend tertiary institution of learning and 1.50% of respondents attend non-formal education, this showed that majority respondents are graduate and educated and based on the knowledge, it help them to facilitate better understanding and making used of the knowledge impacted on them during the training programmed. Occupation is the activity one engages the majority of respondents are unemployed which is 54.40% and this shows they are so eager to learn the training exercise so that to become self-employed, while 20.60% of respondents are engages in business activities; this is because they have

something to do that is reason why their participation is low. Marital status is also had an important role to play due to tradition and norms and values in the society but never the less the essence of the training is to empowered women to become self-employed and to handle some of the family responsibilities and this shows that majority of the respondents are married which 60.30% and less is 2.90% of respondents are divorcee and this shows that married and other societal does not prevent training participation of both men and women.

Conclusion

It was concluded that the most of the participant on training are unemployed youth and women and it was found that training is beneficial to them

Recommendations

1. Starter pack such as plastic tank, pelletizing machine should be given to the participant.
2. Soft loan should be given to the participant through the agricultural bank or from cooperative union.
3. Fisheries expert from the college should visit the established farms from time to time.

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Effect of Bitter leaf meal diets on Digestibility and Nutritive values of *Clarias gariepinus* (Burchell, 1822)

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Abstract

Phytogenic additive improves productivity through enhancement of digestibility, while proximate profiles are important in ensuring that they are within the range of dietary requirement and meeting commercial specifications Therefore, effect of bitter leaf (*Vernonia amygdalina*) meal (VAM) diets on digestibility, proximate and mineral contents of *Clarias gariepinus* were determined using standard methods. Data were subjected to descriptive statistics and Analysis of variance (ANOVA) (α 0.05). Highest Apparent digestibility coefficient (ADC) value $93.30 \pm 1.15\%$ was from VAM6 diet and lowest value $76.07 \pm 1.73\%$

was from VAM2 diet. Apparent digestibility of crude protein (ADCP) ranged from $59.67 \pm 0.13\%$ to $64.79 \pm 0.04\%$. The highest value was from the control diet (VAM1), while the lowest was from VAM2 diet. The proximate compositions of the crude protein (CP) and Crude lipid (CL) showed that the highest values ($66.58 \pm 0.66\%$; $10.43 \pm 0.03\%$) were from the carcasses fed VAM2 diet and the least values ($63.81 \pm 1.70\%$; $9.16 \pm 0.48\%$) were from carcasses fed VAM5 and VAM4 diets respectively. Final carcass calcium and magnesium ion concentrations were from fish fed VAM4 diet, with the highest values ($3.59 \pm 0.21\%$; $0.36 \pm 0.01\%$) from the fish fed VAM4 diet and the least values ($3.22 \pm 0.10\%$; 0.30 ± 0.02) from fish fed control diet (VAM1). The highest values for sodium and potassium were jointly from the carcass fed VAM2 diet and the least values were from the carcasses fed VAM1 and VAM6 diets respectively. Conclusively, the *V. amygdalina* additive had no negative influence on the digestibility and nutritive values of *C. gariepinus*.

Keywords: Fish farming, phytochemicals, digestion, proximate profiles, *Clarias gariepinus*

Introduction

Plants with medicinal properties have been used to treat various ailments affecting man and animals since time immemorial (Hossain *et al.*, 2015). Furthermore, these herbs and plant extracts that were utilized in animal feed are called phytochemicals or herbal feed additives. The inclusion of these phytochemicals additive in animal feed can improve productivity through the enhancement of digestibility, nutrient assimilation and destruction of pathogens resident within the animal gut (Dantas *et al.*, 2008; Maidala *et al.*, 2017). These promoters are now recognized in many farmed animal species such as the broiler industry as additives to shorten the period for attaining the market weight by stimulating growth, improving feed efficiency and survivability of broilers (Hossain *et al.*, 2015), and also in rabbit to improve health. However, their adoption in aquaculture industry is gaining attention in recent times (Adewole, 2021; Fatokun *et al.*, 2019).

In Nigeria, millions of naira is spent annually on feed additives such as Vitamin-mineral premix (VMP), antibiotics, antioxidants which may have negative effect on the animals and human beings (Adewole, 2016; Maidala *et al.*, 2016; Ogbe and John, 2011). It is therefore necessary to source for cheaper alternative feedstuffs such as leaf meal that can efficiently replace the expensive conventional chemical substances such as VMP, antibiotics and other additives.

Vernonia amygdalina is a dark green vegetable known as bitter leaf in English, and “ewuro” in Yoruba land (Bosch *et al.*, 2005). The roots and leaves are used in phytotherapy to treat fever, hiccups, kidney disease and stomach discomfort, and as antihelminthic and antimalarial (Gill, 1992). Furthermore, plants such as *Vernonia amygdalina*, *Moringa oleifera*, *Occimum spp*, *Celocia argentea*, *Manihot spp*, *Telferia occidentalis*, *Chromolaena odorata* amongst others are rich in reasonable quantity of vitamins, minerals, amino acids and antioxidants (Aro *et al.*, 2009; Ogbe and John, 2011; Adegbenro *et al.*, 2012a). Adegbenro *et al.*, (2012b) reported that the leaves of these plants could adequately replace conventional vitamin-mineral premix in livestock diet either singly or as composite mixture and helps to lower dependence of farmers on the imported VMP, reduce the cost of production and it also reduce the consumer's concern on the toxicity of synthetic origin of the VMP (Botsoglou *et al.*, 2002). Performance and production economy of Bitter leaf (*Vernonia amygdalina*) as dietary additive fed to *Clarias gariepinus* have been reported by (Adewole, 2015; 2016) respectively. These reports showed the improvement in the growth of the fish and the economic advantages of using *V. amygdalina* leaf meal as dietary additive. This is in line with the observation by (Satchithanandam *et al.*, 1990) that alteration in physiological process of animal was based on feeds and feed intake.

However, the determination of some proximate profiles such as protein content, lipid, ash and other nutrients is often necessary to ensure that they are within the range of dietary requirement and commercial specifications (Watchman, 2000). The study of micro-nutrients present in living organisms is of biological importance because many of such micro-nutrients take part in some metabolic processes and are known to be indispensable to all living things (Shul'man, 1974). This research is therefore conducted to determine the digestibilities, proximate and mineral contents of *Clarias gariepinus* fed graded levels of *V. amygdalina* meal diets.

Materials and methods

Proximate composition of the ingredients, diets and fish carcass before feeding trials

The proximate composition of the ingredients, diets and fish flesh were carried out at the Institutes of Agricultural Research and Training Laboratory (IART), Moor Plantation Ibadan, Oyo State. All the six isonitrogenous based diets were, separately analysed for crude protein, crude fibre, crude fat, ash, Nitrogen Free Extract (NFE), moisture, gross energy and minerals as recommended by A. O. A. C (2000). Similarly, experimental fish samples carcasses and ingredients such as fish meal, yellow maize, soybean and groundnut cake were taken for chemical analysis based on the method of A.O.A.C (2000). A mean of three samples for each nutrient was taken.

Statistical Analysis: Means of data generated were subjected to One-way Analysis of variance at 5% probability level

Results and Discussion

Apparent digestibility coefficient ranged from 76.07 ± 1.73 – $93.30 \pm 1.15\%$. The highest value was from VAM6 diet, followed closely by $90.43 \pm 1.15\%$ from VAM5 diet, while the lowest was from VAM2 diet respectively. The inclusions at middle and upper extremities had positive influence on the apparent digestibility coefficient of the fish. The fish fed the VAM5, VAM6 diets had significantly higher ($p < 0.05$) apparent digestibility coefficient than VAM3, VAM4, VAM1 diets which are significantly different from VAM2 diet (Table 1). Apparent digestibility of dry matter ranged from 71.12 ± 0.30 to $84.31 \pm 0.01\%$. The inclusions at lower extremities had positive influence on the apparent digestibility of dry matter of the fish. The highest value was from VAM3 diet, followed by $82.95 \pm 1.37\%$ from VAM2 diet, while lowest was from the control diet respectively. The fish fed VAM2, VAM3, VAM6 diets had significantly higher apparent digestibility of dry matter than VAM4 diet, which is significantly different from VAM2 diet (Table 1). Apparent digestibility of crude protein ranged from $59.67 \pm 0.13\%$ to $64.79 \pm 0.04\%$. The highest value was from the control diet, followed closely by $62.75 \pm 0.18\%$ from VAM4 diet, while the lowest was from VAM2 diet respectively. The fish fed the control VAM1, VAM3 and VAM4 diets had significantly higher ($p < 0.05$) apparent digestibility of crude protein VAM5, which is significantly different from VAM2, VAM6 diets (Table 1). Apparent digestibility of gross energy ranged from 66.15 ± 0.02 to $67.24 \pm 0.01\%$. The highest value was from the control diet, followed closely by 66.86 ± 0.02 from VAM6 diet, while the lowest was from VAM2 diet. The fish fed the control diet, VAM6 diets had significantly higher ($p < 0.05$) apparent digestibility of gross energy than VAM4, VAM5 diets, which are significantly different from VAM3 diet (Table1).

The gross energy intake varied from 3785.55 ± 61.69 to 5474.95 ± 62.99 Kcal/kg. The highest value was from the VAM6 diet, followed closely 5443.33 ± 68.61 Kcal/kg and the lowest was in the fish fed the control diet. The fish fed VAM6, VAM4, VAM5, VAM3 diets had significantly higher ($p < 0.05$) gross energy intake than the fish fed VAM2 diet, which is significantly different from VAM1 diet (Table 1). The energy retention values ranged from $18.59 \pm 0.68\%$ to 26.73 ± 1.95 . The highest was from the control diet, followed closely by $19.97 \pm 0.57\%$ from VAM2 diets, while the lowest value was from VAM5 diet. The fish fed the control diet had significant higher ($P < 0.05$) energy retention values than the other diets (Table1).

The final carcass moisture content at the end of the experiment ranged from 74.54 ± 1.40 to $76.33 \pm 0.26\%$. The highest final moisture value was from the fish fed the control diet (VA1), followed closely by $76.24 \pm 0.92\%$ from VA5 diet, while the lowest was from the fish fed VAM4 diet respectively. All the final moisture contents were lower than the initial. Within the treatments, there was no significant difference ($P > 0.05$) between the moisture contents of fish fed the control diet and the other treatments /diets (Table 2). The final carcass crude protein content ranged from 63.81 ± 1.70 to $66.58 \pm 0.66\%$. The highest final crude protein value was from the fish fed VAM2 diet, followed closely by $65.26 \pm 1.13\%$ from the fish fed control diet and the lowest crude protein value was from the fish fed VAM5 diet. All the final crude proteins were higher than the initial. Within the treatments, there was no significant difference ($P > 0.05$) between the protein contents of fish fed the control diet and the other treatments /diets (Table 2).

The final carcass crude lipid contents ranged from 9.16 ± 0.48 to $10.43 \pm 0.03\%$. The highest crude lipid value was from the VA2, followed closely by $10.41 \pm 0.17\%$ from the fish carcass fed VA3 diet, while the lowest crude lipid was from the fish fed VA4 diet respectively. All the final carcass crude lipid values were higher than the initial. Within the treatments, the fish fed VA2, VA3 diets had significantly ($P < 0.05$) higher crude lipid contents than the others (VA1, VA4, VA5 and VA6 diets) respectively (Table 2). The final carcass crude fiber content ranged from 1.32 ± 0.02 to $1.43 \pm 0.03\%$. The highest final carcass crude fiber

was jointly from the fish fed VA2, VA4 diets, followed by $1.40 \pm 0.04\%$ from the carcass of fish fed VA3 diet, while the lowest crude fiber content was from the fish fed the control diet respectively. All the final carcass crude fiber contents were higher than the initial. Within the treatments, there was no significant difference ($P>0.05$) between the fiber contents of fish fed the control diet and the other treatments /diets (Table 2). The final crude ash contents ranged from $17.05 \pm 0.03\%$ to $17.50 \pm 0.07\%$. The highest final carcass crude ash content was from the fish fed VA5 diet, followed closely by $17.49 \pm 0.23\%$ from the fish fed VA4 diet, while the lowest final crude ash content was from the fish fed the control diet respectively. All the final carcass crude ash contents were higher than the initial. The fish fed VA4 and VA5 diets had significantly higher ($p<0.05$) crude ash than/compared to control diet, but not significantly different from VAM2, VAM3 and VAM6 diets respectively (Table 2).

The final carcass nitrogen free extract contents ranged from 4.40 ± 0.65 to $7.88 \pm 1.78\%$. The final carcass nitrogen free extracts were lower than the initial. The highest value was from the fish fed VAM5 diet, followed closely by $7.11 \pm 1.51\%$ from the fish fed VAM4 diet, while the lowest value was from the fish fed VAM2 diet respectively. Within the treatments, there was no significant difference ($P>0.05$) in the final carcass nitrogen free extract contents between the control diet and the other treatments, there was no significant difference ($P>0.05$) between the highest and lowest nitrogen free extracts in the final carcasses of the fish fed *Vernonia amygdalina* meal diets (Table 2). The final carcasses gross energy contents ranged from 3984.00 ± 0.00 to 4009.00 ± 0.03 (Kcal/g). All the final gross energies were higher than initial. The highest gross energy was from the fish fed VA6 diet, followed closely by 4003.00 ± 0.04 (Kcal/g) from the fish fed VAM4 diet, while the lowest value was from the fish fed control diet. Within the treatment, the fish fed diet the control diet had insignificantly lower ($p>0.05$) gross energy compared to others (Table 2). There was no significant difference ($P>0.05$) between the highest and lowest gross energies in the final carcasses of the fish fed *Vernonia amygdalina* meal diet

The mineral element Sodium (Na^+) concentrations ranged from 0.61 ± 0.03 to 0.80 ± 0.04 . The final sodium ion concentrations were higher than the initial. The highest Sodium (Na^+) ion concentration was from the carcass of fish fed VAM2 diet, followed closely by 0.72 ± 0.03 from the carcass of fish fed the control diet, and the lowest value was the carcass of fish fed VAM4 diet respectively. Within the treatment, the fish fed VAM2 diet had significantly higher sodium ion concentrations compared to VAM3, VAM4, VAM5, VAM6 diets, but not significantly different ($p<0.05$) from VA1 control diet. Furthermore the fish fed VA3 diet was significantly higher ($P>0.05$) in sodium ion concentrations compared to fish fed VAM6 diet but not significantly different ($P<0.05$) from VAM4, VAM5 diets respectively (Table 2).

The final carcass Potassium (K^+) ion concentration ranged from 1.30 ± 0.02 to 1.44 ± 0.02 . The final potassium ion concentrations were higher than the initial (Table). The highest potassium ion was from the carcass of fish fed the VAM2 diet, followed jointly by $1.40 \pm 0.08/1.40 \pm 0.08$ from the carcasses of fish fed VAM3 and the control diets and lowest value was the fish fed VAM6 diet. Within the treatments, there was no significant difference ($P>0.05$) between the potassium ion concentrations content of fish fed the control diet and the other treatments /diets (Table 2). There was no significant difference ($P>0.05$) between the highest and lowest potassium ion concentrations in the final carcasses of the fish fed *Vernonia amygdalina* meal diets. The final carcass calcium ion concentrations ranged from 3.22 ± 0.10 to 3.59 ± 0.21 . All the final calcium ion concentrations were higher than the initial (Table 2). The highest calcium ion concentration was from the carcass of the fish fed VAM4 diet, followed closely by 3.51 ± 0.21 from VAM5 diet and the lowest value was from the fish fed control diet respectively. Within the treatments, the fish fed the control diet had insignificantly higher ($p<0.05$) final calcium compared to the others. Within the treatments, there was no significant difference ($P>0.05$) between the calcium ion concentrations content of fish fed the control diet and the other treatments /diets (Table 2). There was no significant difference ($P>0.05$) between the highest and lowest potassium ion concentrations in the final carcasses of the fish fed *Vernonia amygdalina* meal diets. The phosphorus ion concentration ranged from 2.21 ± 0.34 to 2.78 ± 0.05 . All the final phosphorus ion concentrations were higher than the initial. The highest was from the fish fed the control diet, followed closely by 2.58 ± 0.14 from VAM6 diet and the lowest was from the fish fed VAM3 diets respectively. Within the treatments, there was no significant difference ($P>0.05$) between the phosphorous ion concentrations content of fish fed the control diet and the other treatments /diets (Table 2)..There was no significant difference ($P>0.05$) between the highest and lowest potassium ion concentrations in the final carcasses of the fish fed *Vernonia amygdalina* meal diets. The final carcass magnesium ion concentrations ranged from 0.30 ± 0.02 to 0.36 ± 0.01 . All the final magnesium contents were higher than the initial (Table 2) The highest was from the fish fed VAM4, closely followed jointly by $0.32 \pm 0.02 /0.32 \pm 0.00\%$ from

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the fish fed ,VA2, VA5,VA6 diets respectively, while the lowest value was from the control diet. The fish fed VA4 diet had significantly higher ($p<0.05$) magnesium than/compared to control diet, VA3 diets, but not significantly different ($p<0.05$) from VA2, VA5, VA6 diets (Table 1).

Apparent digestibility coefficient of dry matter in mainly used to describe how efficiently feeds or feed ingredients are being digested and how much of their nutrient composition can be made available to fish for maintenance and growth (Fagbenro, 2003). Degain *et.al.*, (1997) opined that apparent dry matter digestibility provides better estimate of the quantity of indigestible materials in the feed rather than the individual nutrient. The apparent digestible dry matter was significantly different in the VAM treated groups and also when compared with the control. It improved from 71.72-82.95%. The values of dry matter digestibility in the present study were higher than (55.76-77.99%) reported for West African Dwarf (WAD) ewe fed graded levels of *V. amygdalina* leaf meal diets. The favourable digestibility of the dry matter observed here in the present study, was likely to be due to laxative, anti –helminthic potentials (John,1994) and beneficial effect of tannins (Athanasiadou *et.al.*,2005) and protein quality of VAM supplementation in the diets.

The apparent digestibility of protein improved from 59.67% to 64.79%.. This observed value might be the effect of increased faecal nitrogen output (Komolong *et.al.*,(1999), when weaner sheep were fed basal diet of Lucerne hay and dosed with quebracho tannin. Also Dabrowski and Kozak (1979) ascribed poor protein utilization with soya diets fed grass Carp (*Ctenopharyngodon idella*) due to incomplete destruction of anti-nutritional factors by heat processing and were also deficient in available lysine and sulphur amino acids. While Noreen and Salim, (2008) reported better protein digestibility and utilization for soybean meal could be due to the reason that *Labeo* might be less sensitive to the anti-nutritional factors present in Soybean meal as other fish species. The lowest value of VAM6 digestible protein might not be unconnected with the fact that the VAML used here were not processed by boiling or washing with cold water or salt solution, indicate highest content of both protein and anti-nutritional factors. The digestible gross energy, gross energy intake were significantly higher in the VAM diets compared with the control and significantly lower energy retention compared to the control diets indicates the preference for all the VAM's diet over the control or (VAM4)diet over the control or other higher inclusion diets, thus accounting for the better ($p<0.05$) performance obtained from fishes fed VAM's diets. The apparent gross energy values obtained in the present study was similar to (53.5-84.9%) (Noreen and Salim, 2008), for various ingredients, but lower than the reported values for Silver Carps ($75\pm0.71-78\pm0.88\%$) by Nwanna and Akanbi, 2003).

Table1: Digestibility Parameters of *Clarias gariepinus* fed Bitter leaf (*Vernonia amygdalina*) meal diets

PARAMETERS	VAM1	VAM2	VAM3	VAM4	VAM5	VAM6
Apparent Digestibility coefficient	80.86 $\pm$ 1.15 ^b	76.07 $\pm$ 1.73 ^c	81.31 $\pm$ 0.58 ^b	83.72 $\pm$ 1.73 ^b	90.43 $\pm$ 1.15 ^a	93.30 $\pm$ 1.1
Digestible dry matter (%)	70.94 $\pm$ 0.44 ^d	82.95 $\pm$ 1.37 ^a	84.31 $\pm$ 0.01 ^a	73.91 $\pm$ 0.01 ^c	71.72 $\pm$ 0.14 ^d	76.01 $\pm$ 0.0
Digestible crude protein (%)	62.75 $\pm$ 0.18 ^b	59.67 $\pm$ 0.13 ^d	62.56 $\pm$ 0.15 ^b	64.79 $\pm$ 0.04 ^a	61.69 $\pm$ 0.15 ^c	59.79 $\pm$ 0.1
Digestible gross energy (%)	64.79 $\pm$ 0.04 ^a	62.75 $\pm$ 0.18 ^b	66.56 $\pm$ 0.01 ^d	66.75 $\pm$ 0.03 ^c	66.78 $\pm$ 0.01 ^c	66.86 $\pm$ 0.0
Gross energy intake (kJ/kg)	3785.55 $\pm$ 61.69 ^c	5091.18 $\pm$ 176.87 ^b	5210.60 $\pm$ 145.04 ^{ab}	5443.33 $\pm$ 68.61 ^a	5537.22 $\pm$ 62.99 ^a	5474.95 $\pm$ 79 ^a
Mean energy intake (kJ/100g)	236.60 $\pm$ 3.86 ^c	267.96 $\pm$ 9.31 ^b	306.50 $\pm$ 8.53 ^a	302.41 $\pm$ 3.81 ^a	307.61 $\pm$ 3.49 ^a	304.16 $\pm$ 4.
Daily energy intake (kg/fish/day)	2.82 $\pm$ 0.04 ^c	3.19 $\pm$ 0.11 ^b	3.65 $\pm$ 0.10 ^a	3.60 $\pm$ 0.05 ^a	3.66 $\pm$ 0.04 ^a	3.62 $\pm$ 0.05
Daily energy gain (kg/100g/fish)	12.01 $\pm$ 0.70	12.11 $\pm$ 0.60	12.09 $\pm$ 0.67	12.26 $\pm$ 0.47	12.24 $\pm$ 0.35	12.33 $\pm$ 0.3
Mean energy gain	0.75 $\pm$ 0.04 ^a	0.64 $\pm$ 0.03 ^b	0.71 $\pm$ 0.04 ^{ab}	0.68 $\pm$ 0.03 ^{ab}	0.68 $\pm$ 0.02 ^{ab}	0.69 $\pm$ 0.02
Energy retention (kJ/100g)	26.73 $\pm$ 1.95 ^a	19.97 $\pm$ 0.57 ^b	19.46 $\pm$ 0.65 ^b	18.94 $\pm$ 0.92 ^b	18.59 $\pm$ 0.68 ^b	18.94 $\pm$ 0.7

Data mean values with different superscripts in each row are significantly different $P>0.05$.

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Table2: Digestibility parameters of *Clarias gariepinus* fed Bitter leaf (*Vernonia amygdalina*) meal diets

Parameters	Initials	VAM1	VAM2	VAM3	VAM4	VAM5	VAM6
Moisture(%)	78.62±0.01	76.33±0.26	76.08±0.87	75.91±0.79 ^b	74.54±1.40	76.24±0.92 ^c	75.51±0.33
Crude protein (%)	62.86±0.01	65.26±1.13	66.58±0.66	63.98±1.47	64.81±1.65	63.81±1.70	65.10±1.67
Crude lipid (%)	8.65±0.01	9.63±0.02 ^b	10.43±0.03	10.41±0.17 ^a	9.16±0.48 ^b	9.41±0.17 ^b	9.56±0.17
Crude fibre (%)	1.28±0.00	1.32±0.02	1.43±0.03	1.40±0.04 ^{ab}	1.43±0.02 ^a	1.39±0.02 ^{ab}	1.37±0.07
Ash (%)	16.68±0.06	17.05±0.03 ^b	17.16±0.01 ^{ab}	17.16±0.01 ^{ab}	17.49±0.23 ^a	17.50±0.07 ^a	17.16±0.18 ^{ab}
Nitrogen Free Extract	10.54±0.05	6.75±1.12	4.40±0.65 ^b	6.90±1.45 ^{ab}	7.11±1.51	7.88±1.78	6.82±1.49
Gross Energy (Kcal/kg)	2974.00±0.00	3984.00±1.15	3991.33±50.52	3989.33±56.08	4003.00±38.96	4002.67±28.95	4009.67±28.48
Sodium (Na)	0.38±0.00	0.72±0.03 ^{ab}	0.80±0.04 ^a	0.69±0.06 ^b	0.61±0.03 ^{bc}	0.62±0.01 ^{bc}	0.57±0.01 ^c
Potassium (k)	1.16±0.00	1.40±0.06	1.44±0.02	1.40±0.08 ^a	1.34±0.07	1.35±0.01	1.30±0.02
Calcium (Ca)	2.96±0.00	3.22±0.10	3.38±0.08	3.28±0.18	3.59±0.21	3.51±0.21	3.57±0.19
Phosphorous (P)	2.08±0.00	2.78±0.05	2.56±0.02	2.21±0.34	2.56±0.10	2.57±0.17	2.58±0.14
Magnesium (Mg)	0.28±0.00	0.30±0.02	0.32±0.00	0.31±0.03	0.36±0.01 ^a	0.32±0.02 ^{ab}	0.32±0.00 ^{ab}

Data mean values with different superscripts in each row are significantly different P>0.05.

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ENHANCEMENT OF FISH FARMING ACTIVITIES VIA THE USE OF MOBILE PHONE TECHNOLOGY AMONG FISH FARMERS IN EPE LOCAL GOVERNMENT AREA

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Abstract: Fish farming is viewed as one of the fastest-growing sectors of Nigeria's economy. It still has not reached its full potential as the sector continues to be hit with inefficiencies in production. This has necessitated the need for everyday technologies like mobile phones to be upgraded to enhance fish farming activities. This study seeks to find out which socioeconomic and farmer characteristics best predict how mobile phones can enhance fish farming activities. Epe local government area was used as the study area. The sample size for the study was forty (40) fish farmers selected through a simple random sampling. The results were analyzed using stepwise regression and revealed that the status of the fish farmer was the best predictor of mobile phone usage in enhancing fish farming. It also found that socioeconomic and farmer characteristics were significant in influencing fish farmers' decision to use mobile phones to enhance their operations. Also, it was revealed that sex, age, years of education, years of farming, status in the household, usage of other ICTs, the extent of use of other ICTs and effectiveness of other ICTs had a significant relationship with mobile phones as a tool to enhance fish farming activities. Therefore, the research concluded mobile phones should be farmer-friendly and also take into consideration farmers' varying socioeconomic and farming characteristics.

Keywords: Enhancement, Fish farming activities, Mobile Phone technology, Fish farmers

INTRODUCTION

Across the globe, about 840 million people lack adequate access to food and about 25% of this population lives in sub-Saharan Africa (FAO, 2002). As the population increases, pressure is put on natural resources, more people become food insecure; lacking access to adequate amounts of safe and nutritious food for normal growth and development, and active and healthy life (Pretty, 1999). Sub-Saharan Africa is characterized by moderate agricultural productivity, widespread economic stagnation, persistent political instability, increasing environmental damage, and severe poverty (Pretty *et al.*, 2003).

Aquaculture offers a key entry point to reach millions of poor people in Africa, improve the nutrition and health of families, alleviate poverty, and become an active agent of economic development and social change (Bene and Hecks, 2005). The Aquaculture sector has a role to play in ensuring the demand for fish as a protein source is met. It is one important source of animal protein supply for human consumption (Bailey *et al.*, 1996). With the world population expected to reach nine billion by 2050, the aquaculture sector will play a key role in ensuring food and nutrition security as the increased demand will challenge fish production over the coming decades (FAO, 2017).

Federal Department of Fisheries (1997) reported that in Nigeria, a higher percentage of fish farmers operate small-scale farms ranging from homestead concrete ponds (25-40 meters) to small earthen ponds (0.02-0.2 hectares). Small scale fish farming supplies the greatest percentage of the Nigerian's annual fish production output (FDF, 1997). One of the needs of fish farmers is information, which should be accurate and timely. While agricultural extension agents have been doing their best to disseminate agricultural information to fish farmers, the overwhelming number of fish farmers makes it difficult for extension agents to effectively reach all the farmers. The adoption of faster and more efficient communication channels will benefit the fish farmers. The internet mobile phone is an alternative to the traditional information dissemination by extension agents. These are communication tools that, if integrated into agricultural extension delivery, would ease the flow of information to fish farmers (Chhachhar & Hassan, 2013). The volume of information contained on the internet cannot be quantified, while the use of mobile phones has made communication easier and faster.

Though these communication tools have been employed in many sectors with desirable results, the use of the internet and mobile phones by fish farmers in the Epe local government area of Lagos state will

grant them better access to agricultural information, and enhance their production capabilities. It is necessary for the fish farmers to have access to the internet and mobile phones, and also make use of them. Therefore, the objectives of the study are;

1. To describe the socioeconomic and farmers characteristics of fish farmers
2. To measure mobile phone enhancement of fish farming activities of fish farmers
3. To find out the relationship between mobile phones and socioeconomic and farmer characteristics in enhancing fish farming activities.
4. To find the best predictors of mobile phones enhancing fish farming activities, and
5. To examine constraints limiting the use of mobile phones in enhancing fish farming activities

The hypothesis the holds that;

H₀: Socioeconomic and farmer characteristics do not influence fish farmers' mobile usage in enhancement;

H₁: Socioeconomic and farmer characteristics do not influence fish farmers' mobile usage in enhancement

Materials and Methods

Study Area

Epe Local Government covers 965 sq. km with its headquarters being Itamarun. The local area is located within Lagos State, Nigeria on the northern side of the Lekki Lagoon. It lies approximately 90km from Ibadan in Oyo state. The lies within the coordinates 6°35'N 3°59'E. According to the 2006 population census, the area has an estimated population of 181,409. The area has fishing as its major occupation. The climate is that of the equatorial with dry (November to March) and wet seasons (April to October). The temperature in the area ranges from 25°C to 35°C yearly with high relative humidity. Topography and climate favour the development of fish farming and fishing activities.

Procedure

The study adopted the cross-sectional survey design to help measure the interrelationship that exists between the socio-economic and farmer characteristics of fish farmers and Mobile Phone extent of use. The research used a simple random sampling procedure to select fish farmers in the area. The research adopted the simple random sampling technique in selecting 40 respondents for the study. A structured questionnaire was used for the data collection making it primary data. The questionnaire was grouped into two with the first being the socioeconomic and farmer characteristics of fish farmers, the second being the use of ICTs, and the extent of usage and effectiveness of these ICTs in their activities.

Data Analysis

The data collected was processed and stored using Microsoft Excel and SPSS 25.0 for the analysis. The data analysis was done using descriptive statistics (frequency, percentage, and graphs) for the socio-economic and farmer characteristics of fish farmers. Socio-economic characteristics, usage, the extent of use, and effectiveness of ICTs use were used to predict farmers' mobile phone usage enhancing fish farming. Ordinary Least Square (OLS) regression was used to regress socio-economic and farmer characteristics on mobile phone usage enhancing fish farming. Mathematically;

$Y = X_i \beta + \epsilon$, where Y = Mobile phone extent of use COVID-19, X_i = Socio-economic characteristics ϵ - Error term

Table 1: Definition of Variables

Variables	Measurement	Tolerance	VIF	Mean ± SD
Dependent Variable				
Mobile extent usage Phone of use	Continuous variable			5.375 ± 1.385
Independent Variable				
Age	Continuous variable	.785	1.274	2.434 ± .982
Sex	1- Male 0- Female			
Household size	Continuous variable	.996	1.004	1.500 ± .508
Years of education	Continuous variable	.994	1.006	3.813 ± .780

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Years of farming	Continuous variable	.919	1.008	2.281±.729
Membership of FBO	1- Yes 0-No	.941	1.063	
Credit source	1- Self- Financing 0- others	.938	1.066	
Land ownership	1- Own 0-others	.997	1.003	
Farm size	Continuous variable	.933	1.071	1.125±.421
Status in household	1- Head 0-others	1.000	1.000	
Other ICT usages	Continuous variable	.984	1.016	15.313±1.354
Other ICT extent usage	Continuous variable	.980	1.021	17.313±3.505
Other ICT effectiveness	Continuous variable	.990	1.010	16.531±4.212

Results and Discussion

Socioeconomic and farmer characteristics of fish farmers

The socioeconomic characteristics of fish farmers in Epe's local area are presented in Table 2. It revealed that the majority of the fish farmers were male (82.5%) with an evenly distributed household number of 3-4 (50%) and 5-6 (50%). With the status of respondents in the household, it was revealed that most of the respondents were the head of their respective household (70%) and they mostly self-financed their fish farming activities (95%). Most of these fish farmers were not part of any farmer-based organization (52.5%) at the time of the research mainly because they deem fish farmer-based organizations as a waste of time and inefficient. Also, farmlands were mostly self-owned lands (82.5%) because renting and family do not ensure efficiency due to inferences from family and landowners. The majority of fish farmers farmed <2.5 acres at the time of the research. Furthermore, the socioeconomic characteristics of fish farmers, revealed that 40% of fish farmers were between the ages of 39-45. This shows that the fish farming population are mostly a youthful population indicating that fish farming in the Epe local area is the prospect of creating jobs for most people. On education, it was revealed that the majority of fish farmers had high years of education translating to high levels of education. This indicates that fish farming requires the farmer to have some level of education to understand and practice fish farming effectively. From Table 1, the majority of fish farmers had a longer period of fish experience. The majority of the fish farmers had 10-14 years of working experience (50.0%), which shows that these farmers have been practicing fish farming for quite a long while and have appeared the benefits that come from it.

On ownership of mobile phones, it was revealed that 95 percent of fish farmers own mobile phones with the majority of the mobile phone being self-purchased phones (70 %). There was generally a high level of mobile phones among fish farmers.

Table 2: socioeconomic and farmer characteristics of fish farmers

Socioeconomic characteristics	Frequency	Percentage
Sex		
Female	7	17.5
Male	33	82.5
Age		
25-31	7	17.5
32-38	14	35.0
39-45	16	40.0
46-52	2	5.0
>52	1	2.5
Years of Education		
1-5	3	7.5
6-10	29	72.5
11-15	6	15
16-20	1	2.5
21-25	1	2.5
Farming Experience		

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1-4	5	12.5
5-9	15	37.5
10-14	20	50.0
Household size		
3-4	18	50.0
5-6	18	50.0
Status in household		
Head	28	70.0
Spouse	7	17.5
Child	5	12.5
Membership of FBO		
Yes	19	47.5
No	21	52.5
Source of credit		
Self-financing	38	95.0
Family/ friends	2	5.0
Land Ownership		
Own land	33	82.5
Family land	5	12.5
Rented land	2	5.0
Farm size (acres)		
< 2.5	34	85.0
2.6-5.5	5	12.5
6.5-10.5	1	2.5
Ownership of Mobile Phone		
Yes	38	95.0
No	2	5.0
Access to Mobile Phone		
Purchase	28	70
NGO	2	5.0
Family and Friends	10	25
Level of Accessibility of Mobile Phone		
High	15	37.5
Moderate	11	27.5
Slight	10	25.0
Not	4	10.0

Mobile Phone Usage Enhancement of fish farming Activities

Types of Mobile Phones used by fish farmers

The result as illustrated in figure 1 shows that the majority of fish farmers use smartphones in their operations due to the need for timely information online. Also, the use of smartphones was preferred over the non-smartphone because of the inconsistency of extension services providers in the study area.

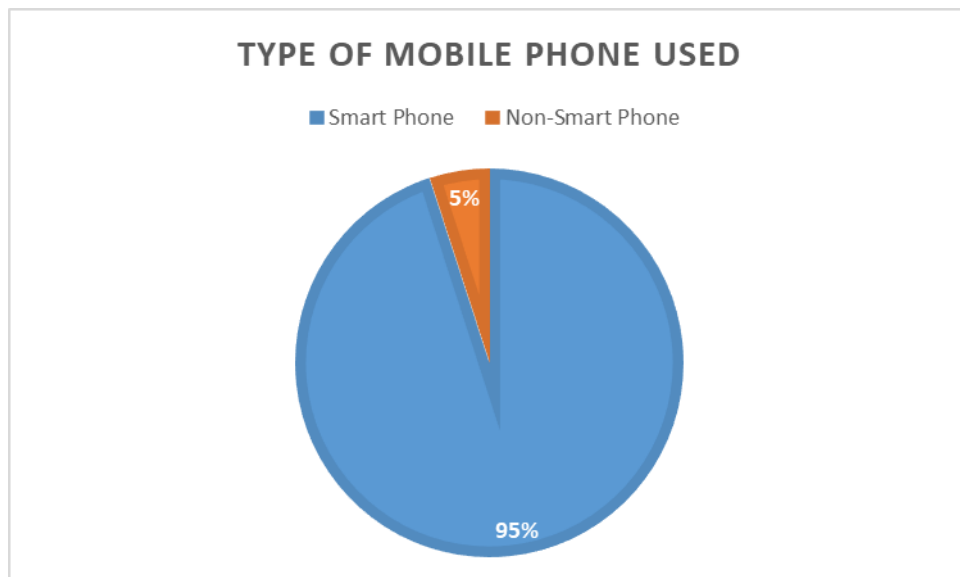


Fig 1: Types of Mobile Phones Used by fish farmers

Network Providers

The study revealed in figure 2, that there were four (4) network providers in the study area. The most used network was Airtel (30 percent) followed closely by MTN (27.5 percent), GLOBACOM (25 percent) and ETISALAT (17.5 percent). According to fish farmers, Airtel was the most preferred because of their network coverage and internet packages that allow for a long browsing experience at limited cost.

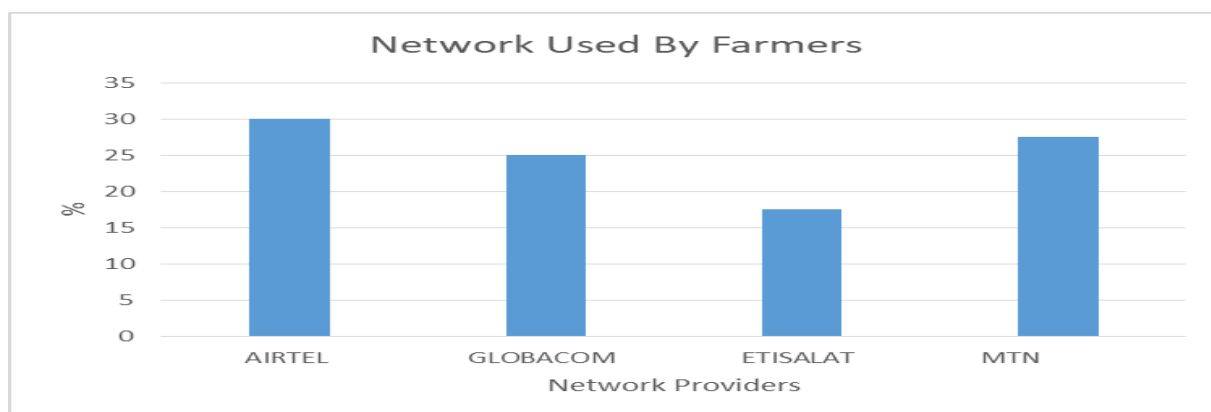


Fig 2: Networks Used by fish farmers

Service Quality by Network Providers

In figure 3, fish farmers' evaluation of network work service quality was reported. It was reported that 87.5 percent of fish farmers said "yes" to the network providers who were providing quality services to them in terms of browsing experience and calls, while 12.5 percent disagreed.



Fig 3: Service Quality provided to fish farmers

Rating the level of tariff by the network provider(s)

Figure 4 below shows fish farmers' rating of the level of tariff charged by their various network providers in the study area. It was revealed that the level of tariff charges according to fish farmers was "moderate" (37.5 percent). This shows that network providers' charges were not extremely high or low. This shows that fish farmers are not much worse off.

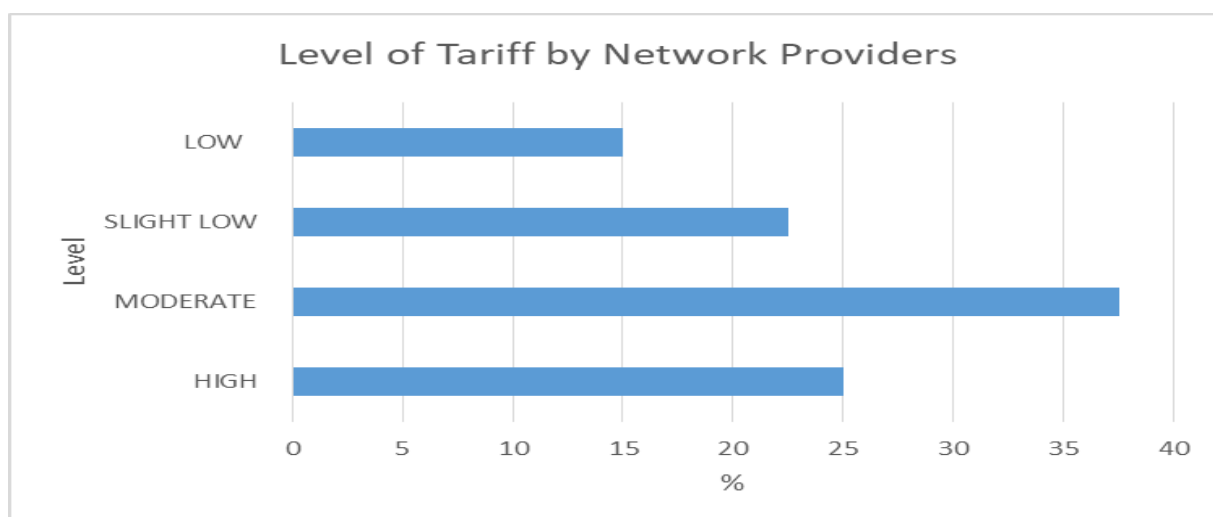


Fig 4: Service Quality provided to fish farmers

Mobile Phone Enhancement of fish farming activities

Figure 5 shows the distribution of fish farmers' responses to mobile phones enhancing their fish farming activities. It was revealed that 97.5 percent said "yes" mobile phone has enhanced their fish farming activities with 2.5 percent disagreeing with the assertion mobile phone has enhanced fish farming activities. The results show that the mobile phone is an integral part of fish farming in terms of meeting information and communication needs.

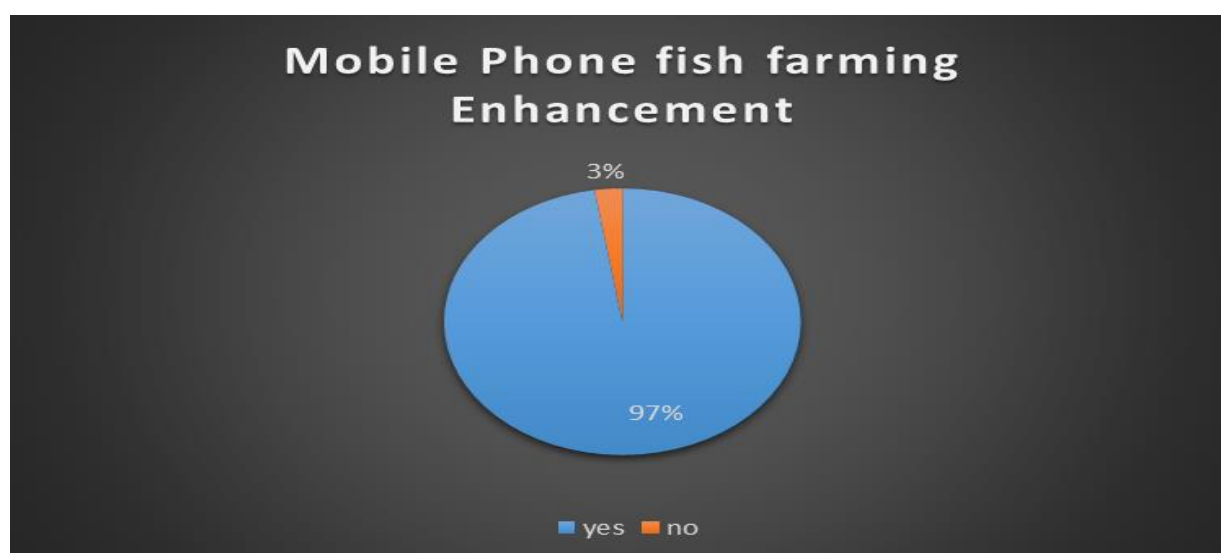


Fig 5: Mobile Phone Enhancement of fish farming activities

Areas of fish farming Enhanced

Table 3 shows the areas of fish farming activities enhanced by mobile phone usage. It was revealed that fish farmers strongly agreed that mobile phone has enhanced their market information (50 percent), Technical guidance (55 percent), integration of farm produce price (52.5 percent), credit facilities (57.5 percent), fish production (50 percent), fish harvesting (47.5 percent) and fish storage (45 percent). However, disease control had 50 percent agreement. The results show that mobile phone is integral to fish farming activities of fish farmers.

Table 3: Areas of fish farming Enhanced

Areas of fish farming	SA	A	N	D	SD	TOTAL
Market information	20	18	1	1	1	40
Technical guidance	22	13	2	1	2	40
Integration of farm produce price	21	14	1	2	2	40
Disease control	12	20	1	6	1	40
Credit facilities	23	10	1	4	2	40
Fish production	20	10	1	2	7	40
Fish harvesting	19	12	2	3	4	40
Fish storage	18	14	2	4	2	40

Relationship between mobile phone enhancement and socioeconomic and farmer characteristics

In table 3, the relationship between mobile phone enhancement and socioeconomic and farmer characteristics was computed using Pearson correlation and spearman rank-order correlation respectively. The use of the two correlation approaches was to find out the relationship and the extent of the relationship between mobile phone enhancement and socioeconomic and farmer characteristics. Table 3 reveals that 8 out of 13 of the independent variables had a significant relationship with mobile phone enhancement. The non-significant variables include; household size ($r=.169$, $p=0.324$), access to credit ($r=-.348$, $p=0.028$), membership of FBO ($r=.152$, $p=0.174$), Land ownership ($r=-.069$, $p=0.326$) and farm size ($r=-.064$, $p=0.340$). This indicates that the stated variables are not related to mobile phone enhancement.

Table 3: Correlation between mobile phone enhancement and socioeconomic and farmer characteristics

Independent variables	Correlation coefficient (r)	P-value	Type of correlation	Strength of correlation
Sex	.348	.028	Biserial	moderate

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Age	-.245	.064	Point biserial	Low
Household size	.169	.324	Point biserial	negligible
Years of education	.339	.037	Point biserial	moderate
Years of farming	-.319	.054	Biserial	moderate
Membership of FBO	.152	.174	Point biserial	negligible
Credit source	-.037	.411	Point biserial	negligible
Land ownership	-.069	.326	Point biserial	negligible
Farm size	-.064	.340	Point biserial	negligible
Status in household	.359	.023	Spearman	moderate
Other ICT usages	.276	.085	Biserial	Low
Another ICT extent usage	-.274	.087	Spearman	Low
Other ICT effectiveness	-.259	.053	Biserial	Low
			Point Biserial	Low

p>.05

Stepwise regression predictor of mobile usage enhancement among fish farmers

Table 4, looks at the best predictor of mobile usage enhancement among fish farmers in the Epe local area. It was revealed the best predictor of mobile usage enhancement among fish farmers is the status of the fish farmer in the household. The result shows that if a fish farmer is the head of the household, then the chances of having his mobile phone usage enhances increases by 1.680 and this was found to be significant at $p>.05$. This implies that since the household head has access and control to the household resource, he turns to have control over how, when and the extent to which mobile phones could be used on the fish farm. Hence, if the head of the household uses a mobile phone often for fish farming, then we expect to increase productivity. This is consistent with FAO (2010) who also reported household head access and control of household resources turns to determine the usage of technologies such as mobile phones to enhance farming activities.

Table 4: stepwise regression between socioeconomic and farmer characteristics against mobile usage enhancement

variable	β	SEE	t	Sig.	R	R square	Adj. R square	R square change	Sig. F change
Constant	4.273	.344	12.407	.000					
Status	1.680	.425	3.951	.000	.585	.342	.320	.342	.000

p>.05

H0: Socioeconomic and farmer characteristics do not influence fish farmers' mobile usage in enhancement

H1: Socioeconomic and farmer characteristics do not influence fish farmers' mobile usage in enhancement

Table 5, revealed that the regression of socioeconomic and farmer characteristics on fish farmers' mobile usage in enhancement shows that Socioeconomic and farmer characteristics influence fish farmers' mobile usage enhancement at a significant value of 1%. Therefore, we reject the null hypothesis which says "Socioeconomic and farmer characteristics do not influence fish farmers' mobile usage enhancement". Hence it shows that mobile phone enhances fish farming activities.

Table 5: ANOVA Table

Model	Sum Squares	df	Mean Square	F	Sig.
Regression	20.366	1	20.366	15.612	.000
Residual	39.134	30	1.304		
Total	59.500	31			

p>0.05

Constraints limiting the use of mobile phones in enhancing fish farming activities

Table 5 shows the constraints limiting fish farmers' usage of mobile phones to enhance their fish farming activities. It was revealed that the major constraint faced by fish farmers in using mobile phones to enhance their activities was "rural poverty" (72.5 percent) with the least being "misplacement of phones" (40 percent). Other constraints were erratic power supply (52.5 percent), High cost of mobile phones (37.5 percent), Fluctuating service (42.5 percent), Repairs of technical fault (50 percent), and Problems of theft (72.4 percent).

Table 5: Constraints limiting the use of mobile phones in enhancing of fish farming activities

CONSTRAINTS	SA	A	N	D	SD	TOTAL
High cost of mobile phones	15	8	2	8	7	40
Fluctuating service	17	8	4	7	4	40
Erratic power supply	21	10	5	2	2	40
Repairs of technical fault	20	8	2	7	3	40
Misplacement of phones	10	7	1	12	10	40
Rural poverty	29	11	2	4	3	40
Problem of theft	21	9	1	4	6	40

Conclusion and Recommendation

In conclusion, the study revealed that socioeconomic and farmer characteristics have important role in determining the usage of technologies like mobile phones for their farming activities. It was revealed that mobile phone is common to fish farmers and they use it mostly for contacting client, suppliers and extension agents. Only a few of them used mobile phone features like searching for fish farming information except weather changes. This shows that the mobile phone has the potential to enhance the fish farming activities of farmers. The results of the study also revealed that sex, age, years of education, years of farming status in the household, usage of other ICTs, Extent of use of other ICTs and effectiveness of other ICTs had a significant relationship with mobile phones' extent of use. Despite the significance of the relationship only status of the fish farmer in the household predicted mobile phone extent of use in enhancing fish farming.

Therefore, the study recommends that the government, the ministry for aquaculture, and stakeholders in aquaculture should invest more into the training of household heads in the usage of mobile phone to enhance their farming productive and we also expect that in doing to other members of the household will learn. Stakeholders in aquaculture should provide financial support to heads of household to make technologies such as mobile phone readily available at low cost. Lastly, mobile phones should be farmer-friendly and also take into consideration their varying socio-economic characteristics.

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